Assessment of the Bay of Fundy sea urchin fishery, Lobster Fishing Area 36

Évaluation de la pêche à l'oursin de la Baie de Fundy, zones de pêche du homard 36

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ABSTRACT

The green sea urchin (*Strongylocentrotus droebachiensis*) commercial fishery was initiated along the coast of southwestern New Brunswick, in the Bay of Fundy, in 1989. The sea urchin fishery was separated into 2 management areas. These 2 areas were assigned the same boundaries as Lobster Fishing Areas (LFAs) 36 and 38. In LFA 36, the existing sea urchin fishery is based on a total allowable catch (TAC) system. The sea urchins are harvested mainly by diving and to a lesser extent by dragging. Presently, there are 14 diver based licence operators and only 4 licensed dragging operators. It is currently managed using a minimum legal size limit of 51 mm test diameter (TD) and by a fishing season. A TAC of 900 t was established in 1996 and it has been in place since. In this assessment, fishing effort, landings trends and catch rates were evaluated using logbook information. In addition, sea urchin size structure, densities and biomass were re-evaluated using diver based survey information. The traditional fishing grounds around Campobello Island, Deer Island, and Letete to Pocologan area were resurveyed in 2002-03 and the results compared with the previous survey results from the 1992-94 surveys. In addition, the expansion area from Maces Bay to Chance Harbour, where no previous surveys had been done, was surveyed in 2002. The TAC and harvesting rates were revised.

Since the establishment of a 900 t TAC in 1996, landings remained below 800 t. However, during the last 4 fishing seasons, urchin landings have exceeded the TAC twice and remained the highest since 1996. There has been a increasing trend in catch per unit effort (CPUE) for both the dive and drag fisheries since 1991-92. The proportion of the catch harvested by divers has fluctuated between 65% (1997-98) and 88% (2003-04). With the exception of Deer Island, where legal size sea urchin densities have decreased, all other areas show no significant differences in densities between the 1992-94 and 2002-03 survey periods. With the exception of immature urchins (< 25 mm TD), the density of urchins was significantly higher in the shallow depth strata (0 - 10 m) during both survey periods. Total biomass has changed little between the 2 survey periods. Estimated fishable biomass appears to have declined, but is not significantly different between the 2 surveys due to a high degree of variability. Based on the established TAC of 900 t, the harvesting rate is estimated to be 7.9%-1.1% higher than the harvesting rate of 6.8% that was approved in 1996. However, the Passamaquoddy Bay area is also fished, but has never been surveyed and, therefore, no biomass estimate for this area is available. For that reason, the 7.9% harvesting rate is an overestimate. A review of the survey design and another survey in the next 2-3 years is recommended.

RÉSUMÉ

La pêche commerciale de l'oursin (*Strongylocentrotus droebachiensis*) a débuté le long des côtes sud-ouest du Nouveau-Brunswick, dans la baie de Fundy en 1989. Cette pêche d'oursin a été divisée en deux zones de gestion. Ces deux zones possèdent les mêmes délimitations que les Zone de Pêche du Homard (ZPH) 36 et 38. Présentement, dans la ZPH 36, la pêche d'oursin est basée sur un système de Prise Totale Alloué (PTA). Les oursins sont pêchés en grande partie avec des plongeurs mais aussi avec des dragues. Actuellement, il y a 14 opérateurs de plongée et 4 operateurs de dragage. Cette pêcherie est actuellement gérée en utilisant une limite de taille légale minimale de 51 millimètres (diamètre du test (DT)) et par une saison de pêche. Une PTA de 900 t a été établi en 1996 et a demeuré en place depuis. Dans cette évaluation, l'effort de pêche, les tendances des débarquements et le taux des prises ont été évalués en utilisant l'information des journaux de bord. De plus, la structure de taille, la densité et la biomasse des oursins ont été réévalués pour la ZPH 36, en utilisant l'information obtenue par des échantillonnages en plongé sous marine. Les lieux traditionnels de pêche aux alentour de Campobello Island, Deer Island et le long des côtes entre Letete et Pocologan ont été échantillonnés en 2002-03 et les résultats ont été comparés avec les résultats du sondage précédent en 1992-94. De plus, un lieu d'expansion de pêche entre Maces Bay et Chance Harbour, où aucun sondage précédent n'avait été faite a été échantillonné en 2002. Le PTA et les taux de capture ont été passés en revue.

Depuis l'établissement d'une PTA de 900 t en 1996, les débarquements sont restés au-dessous de 800 t. Cependant, pendant les quatre dernières saisons de pêche, les débarquements d'oursins ont excédé le PTA deux fois et sont restés les plus hauts depuis 1996. Depuis 1991-92, il y a eu une constante augmentation dans les prises par unité d'effort pour les plongeurs et les dragueurs. La proportion de la prise débarquée par les plongeurs a fluctué entre 65 % (1997-98) et 88 % (2003-04). À l'exception de Deer Island, où la densité d'oursin de taille légale a diminuée, tous les autres secteurs ne montrent aucune différence significative dans la densité d'oursin entre les périodes de sondages de 1992-94 et de 2002-03. À l'exception des oursins immatures (< 25 millimètres DT) la densité d'oursins était significativement plus haute dans les strates de profondeur peu profondes (0 - 10 m) pendant les deux périodes de sondages. La biomasse totale a changé peu entre les deux périodes de sondages. La biomasse d'oursins de taille commerciale semble avoir baissé, mais n'est pas significativement différent entre les deux sondages en raison d'un haut degré de variabilité. Basé sur un PTA de 900 t, le taux d'exploitation présent a été évalué à 7.9 % - 1.1 % plus haut que le taux d'exploitation de 6.8 % établi en 1996. Cependant, le secteur de Baie de Passamaquoddy est aussi pêché, mais n'a jamais été échantillonné et donc aucune évaluation de biomasse pour ce secteur n'est disponible. Pour cette raison le taux d'exploitation de 7.9 % est un surestimés. On recommande une revue des méthodes de sondage et un autre sondage dans les prochain 2 à 3 ans.

1. INTRODUCTION

The green sea urchin (*Strongylocentrotus droebachiensis*) fishery along the coast of southwestern New Brunswick, in the Bay of Fundy, operated at a small scale in the 1950s, 1960s, and the early 1980s. The commercial industry did not actually develop until 1989. The sea urchin fishery in southwestern New Brunswick was separated into 2 management areas. These 2 areas were assigned the same boundaries as Lobster Fishing Areas (LFAs) 36 and 38 (Figure 1). In LFA 36, the existing sea urchin fishery is base on a total allowable catch (TAC) system. The urchins are harvested mainly by diving and, to a lesser extent, by dragging. It is currently managed using a minimum legal size limit of 51 mm test diameter (TD) and by a fishing season. Fisheries based in both LFAs are also eligible to fish in a small adjoining area, LFA 37. The majority of the catch is taken from shallow water coastal areas less than 10 m.

Management and sea urchin fishers were concern about the lack of up to date information on the status of the sea urchin stock. In order to address this lack of information, diver-based sea urchin surveys were initiated during the summer of 2002 and 2003. The objective was to survey the expansion area from Maces Bay to Chance Harbour, where no previous survey had been done, and to resurvey the traditional fishing grounds around Campobello Island, Deer Island, and the area along the coast between Letete and Pocologan (Figures 2, 3, 4, and 5).

This report has the following objectives:

- Evaluate the status of the sea urchin stock in LFA 36 and the impact of the fishery.
- Compare the more recent information with the previous surveys results from the 1992-94 surveys.
- Revise the overall legal biomass estimates and review the total allowable catch.

1.1 BIOLOGY

The green sea urchin, *Strongylocentrotus droebachiensis*, is an echinoderm that is distributed in the Atlantic Ocean from New Jersey to the Arctic, extending south to Britain. It is also distributed in the Pacific Ocean from Washington to Alaska. The animals are omnivorous in nature, although they feed primarily on seaweeds. Sea urchins are most plentiful in shallow waters less than 10 m deep, although they may be found down to 1,200 m. Urchins can be found on virtually any type of substrate, but they generally prefer harder surfaces. The animals have separate sexes, mature at approximately 25 mm test diameter (TD), and spawn in late winter/early spring. The planktonic larvae settle in 8 to 12 weeks. Growth can be quite variable, and is dependent on food supply and environmental conditions. The time estimated to reach commercial size (51 mm TD) may take from 3 to 15 years. Currently there are no estimates of natural mortality available. There is no evidence of mortality due to the infectious disease caused by *Paramoeba invadens* in the Bay of Fundy, as has been experienced in the past along the Atlantic coast of Nova Scotia.

1.2 RECENT MANAGEMENT ISSUES

The sea urchin fishery exploitation rate is currently based on a percentage of fishable biomass (6.8%, implemented in 1996) that was estimated using survey data from 1992-94 (DFO 1996). The last peer-reviewed advice on biomass for LFA 36 was completed in 2000 (DFO 2000). Updated peer-reviewed advice on the fishable biomass is required, including results of resource surveys from 2002 and 2003.

2. THE FISHERY

The LFA 36 sea urchin fishery is currently managed by Fisheries and Oceans Canada (DFO). A Conservation and Harvesting Plan (CHP) was developed in consultation with all the license holders in the fishery. At the present time, all participants must have a personal fisher's registration, and the fishery is subject to owner operator policies. The CHP includes: a minimum size limit (TD of 51 mm or 2.0 in.); sea urchins to be sorted and culled on the fishing grounds as soon as possible, with the culled animals returned to the sea immediately upon being culled and in a manner that causes the least harm; harvesting between sunrise and sunset; mandatory submission of logbooks; and dockside monitoring of 50% of all landings (trips). The season extends from October 1 to May 15. At the inception of the commercial LFA 36 sea urchin fishery in the early 1990s, this fishery was limited entry and the number of licenses by gear type was split evenly. The conversion of a drag license to a dive license is permanent, which is a management measure to gradually move the fishery toward an all-dive fishery. As of 2008-09, there were 14 diver based license operator and only 4 licensed dragging operators. The conversion of a drag license to a dive license is permanent.

The diver-based fishing consists of a maximum of 4 divers in the water and 2 skiffs with a maximum length of 7.3 m (24 ft) each. The skiffs may be used within 457 m (1,500 ft) of the mother boat to tend the divers.

Dragging operations are required to use urchin drags with a maximum opening width of 3 m (10 ft). In addition, dragging operations are subject to mobile gear restrictions that limit access to inshore areas off LFA 36 until the second Tuesday in January, and again starting April 1 until the end of the season to avoid gear conflicts with other fleets and specially designated non-fishing areas.

The fleet operates competitively under a TAC of 900 t. These management measures are reviewed on an annual basis with members of the sea urchin industry.

2.1 LOGBOOKS, LANDINGS, AND CATCH RATES

Landing trends in LFA 36 are analyzed using logbook information. Logbook data are used to calculate effort trends and catch per unit of effort (CPUE) indices for individuals, groups, and locations. Catch rate and effort trends based on the analysis of logbook information is presented as the average kilogram of sea urchin landed per fishing trip (kg/trip) and the total number of fishing trips during each fishing season.

Log information on number of tows, average duration of each tow, or average dive time per diver is only available since 2003. All fishing trips with landings less than 200 kg were not included in the analysis. These trips were considered incomplete due to boat breakdown or bad weather condition. The CPUE information used for the fishing seasons between 1991-92 and 1996-97 comes from the DFO 2000 Stock Status Report (DFO 2000). For that data series, separate urchin landings from drag and dive licences are not available.

During fall 2008, a new type of logbook was introduced, that reported the location of fishing by previously defined fishing areas (Appendix 1). The fishing areas were determined based on biological and fishing characteristics that were previously determined during diver-based surveys and fisheries information from the urchin fishers. However, data from the new logbook were not yet available in time to be analyzed for this report.

3. DIVER BASED SEA URCHIN SURVEYS

3.1 INTRODUCTION

In LFA 36, a seasonal TAC of 900 t was established in 1996 based on biomass estimates from diver based surveys that were done between 1992, 1993, and 1994 in Campobello Island, Deer Island, and Letete to Pocologan fishing areas (Figures 2, 3, and 4). The TAC was set on an estimated total biomass of legal size urchins of 13,245 t (6.8%). Since 1992-94, the sea urchin fishery expanded further along the New Brunswick coast into Maces Bay, and up to the Chance Harbour area (Figure 5).

More recently, urchin surveys were initiated during the summer of 2002 and 2003 and included the newer area of Mace Bay. These initiatives were made possible through Joint Project Agreements (JPA) between the license holder groups, Sea Urchins of New Brunswick Inc., the St. Mary's First Nation, and Fisheries and Oceans Canada.

3.2 MATERIALS AND METHODS

3.2.1. Survey Methods

The 2002-03 survey methods were based on similar diver transect methods used during the 1992-94 surveys (Robinson and MacIntyre 1993, 1995). Although fewer transects were sampled overall, they were located in the exact same positions as in the 1992-94 survey. Only data from locations resurveyed in 2002-03 were compared with the corresponding locations surveyed in 1992-94.

Prior to the start of the 2002-03 sea urchin dive surveys, preliminary information on the distribution of commercially important beds of sea urchin was gathered from urchin logbooks and from confidential interviews with individual fishers. This information was used to define fishing locations of relative importance to be included in the survey.

Three major fishing areas were defined, based on the 1992-94 survey. The Campobello Island area, which included all the fishing locations around Campobello Island (Figure 2), the Deer Island area, which included all the fishing locations around Deer Island, and the surrounding Islands (Figure 3), and the Letete area, which included the coastal fishing locations between Letete and Pocologan (Figure 4). The dive transects that were completed during July, August, and September of 2002-03, were located at the exact same positions as in the 3 fishing areas that were surveyed in 1992, 1993, and 1994 (Figures 2, 3, and 4). The locations that were resurveyed were chosen mainly because of their high importance to the fishery. However, several locations were chosen due to their proximity to home port of the available survey vessels.

A fourth fishing area, called the Maces Bay area that was not part of the fishing grounds during the 1992-93 survey was surveyed in 2002. Maces Bay includes the coastal fishing locations between Maces Bay and Chance Harbour (Table 3; Figure 5). The locations of the additional transects in Maces Bay were determined based on same survey methods used during the 1992-94 surveys (Robinson and MacIntyre 1993, 1995).

The coastline in the new Maces Bay fishing area was divided into fishing locations. Each location was prioritize as high, medium, or low importance based on fisher information. The coastline within each location was then divided every 250 m intervals, and each potential

transect was assigned a number. The position of each transect was selected so that they began at MLW and extended perpendicular to shore. In areas where water depth under 10 m extended longer distances from MLW, additional transects were placed further out at 250 m distance from MLW. Transects were then randomly selected within each location. The number of dive transect within each location was determined based on the size of fishable bottom area within each location and weighted by an importance factor of high: medium: low, (3:2:1). For example, a high importance location was assigned 3 times as many dive transects as a low importance location of the same size.

The transects were laid out with a collapsible 2-meter bar holding 150 m of 3/16" nylon rope wound on a rotating spool. The line was marked with twine markers every meter and with numbered tags every 10 m. At the end of each transect, one of the divers would collapse the bar and rewind the transect line on the rotating spool with the help of an attached handle.

Most transect began at MLW and continued perpendicular to shore up to a maximum distance of 150 m. GPS coordinates were recorded at the beginning of each transect along with a compass heading. Two divers swam side-by-side, jointly holding a 2 m long, foldable bar and counted the urchins as they passed under the bar 1 m on each side of the transect line. At every 10 m interval along the transect line, the divers recorded the numbers of urchins and noted their relative size, depth, and bottom type. Mycrophyte composition and other commercially important benthic species were recorded.

After the completion of each dive transect, a maximum of 4 size frequency samples of 100 urchins each were collected at intervals based on size characteristics previously observed along the transect, and the depth of each sample was recorded. The 4 samples were then brought up to the vessel, and the TD were measured to the nearest millimetre. Approximately 30 urchins of commercial size (> 50 mm TD) were broken open and the roe was graded into 6 categories according to the following description:

1. Grade A light: The roe is a bright yellow color and has a very smooth, firm texture. The roe is 2.5 to 3 cm long and is divided into 2 clear distinct halves by a small vein running down the middle.

2. Grade A dark: The roe is a tangerine orange color and has a smooth, firm texture. The roe is 2.5 to 3 cm long and divided into 2 clear distinct halves by a small vein running down the middle.

3. Grade B light: The roe is a paler yellow color and has a smooth firm texture but softer than Grade A. The roe is 2.5 to 3 cm long and the 2 halves are less distinguishable.

4. Grade B dark: The roe is a paler orange color and has a smooth firm texture but softer than Grade A. The roe is 2.5 to 3 cm long and the 2 halves are less distinguishable.

5. Grade C: The roe is a dark yellow or orange color and has soft rough texture. The roe is 2 cm long and the 2 halves can still be differentiated.

6. Poor quality roe: The roe is red, brown, greyish brown or very dark in color and can be variable sizes. The roe has a very soft texture and has a rough or granular appearance with occasional whitish patches.

Roes rated into the first 4 categories are considered acceptable for market.

3.2.2. Ageing and Growth

A useful tool in assessing the status of a population is by determining the age structure of this population. Robinson and MacIntyre (1997) have demonstrated that populations of sea urchins throughout the southwestern New Brunswick area differ in their size and age distributions, and in some areas could be up to 25 years old. Their results showed a great deal of variation in the age at a particular size, suggesting the animals were limited in their growth potential, probably through lack of food. For example, a 20 mm sea urchin could be between 2 and 10 years old, while a 50 mm sea urchin could range from 4 to almost 25 years.

Robinson and MacIntyre (1997) noted that older urchin do not grow as quickly as younger ones of the same size and that urchins may be older than previously thought. The ageing is based on the number of rings found in the coronal test plates and the rotulas (components of the Aristotle's lantern). The ageing processing methods followed was the same as described by Robinson and MacIntyre (1997). Each ring is assumed to be the equivalent of a year of growth based on similar assumptions as for tree rings or otholytes rings in fishes.

During 2002-03, after completion of each transects the Aristotle's lantern of approximately a dozen sea urchins of various test diameters of legal size urchins ($\geq$ 51 mm TD) were collected for ageing and growth. The lanterns were then brought to the lab and frozen until they could be processed later. The ageing data collected during 2002-03, were compared to previous data collected at similar location during the early 1990s.

3.2.3. Biomass Calculation

The urchin biomass was calculated for each location based on the urchin's size, density, and the relationship between the test diameter and wet weight. Within each location, the total bottom area was estimated for the section between the MLW and the 10 m stratum and the section between the 10 and 20 m stratum. Within each location, the density of urchins in number per meter square was calculated separately for the 2 depth strata, and then the total number and biomass of urchin were summed up for each location. Within each location, the dive transects data were pooled. The size-weight equation (Robinson and MacIntyre 1993, 1995) used in the conversion of the size frequency data is:

Weight (g) = 0.0009947 x Test Diameter (mm) $^{2.77}$.

As in the previous surveys, the total number of urchin and the biomass was estimated for each location. Urchin densities, in number of urchins per square meters (Number of urchins/m^2), based on size groupings, locations, and depth strata were compared between survey periods using ANOVA analysis. In the analysis of variance, only the averages of all the mean densities from each location within each fishing area were compared between survey periods and depth strata.

4. RESULTS AND DISCUSSION

4.1. THE FISHERY

4.1.1. Landings

For the first 6 years, since the inception of this commercial fishery in 1989-90, landings increased dramatically until 1994-95 (Table 1; Figure 6). A TAC of 900 t was established in 1996 and it has been in place for the subsequent 12 years. For the following 7 fishing seasons, landings remained below 800 t and declined to lows of 617 and 619 t during the 1999-00 and 2000-01 seasons. Subsequently, during the 2004-05 fishing season, landings peeked at 1,068 t followed 3 years later by the second highest landing (1,028 t) during the 2007-08 season (Table 1; Figure 6). Landings exceeded the TAC in 1996-97, 2004-05, and 2007-08. During the years when the fleet TAC was exceeded, final landing statistics were summarized only later after the end of the season.

The proportion of the catch in LFA 36 harvested by divers has fluctuated between 65% (1997-98) to 88% (2003-04) and is currently at the long-term average of approximately 77% (Table 1).

4.1.2. Catch Rates

There has been an increasing trend over time in CPUE for both the dive and drag fisheries since 1991-92 (Figure 7). This could be due to improved fishing practices and experience, changing market conditions, or changes in abundance.

In the dive fishery, since the 1991-92 fishing season, the seasonal CPUE per dive trip increased from 519 kg/trip to a peak of 912 kg/trip during 1995-96. Over the next 7 seasons (between 1997-98 and 2003-04), the seasonal catch rate fluctuated between 595 and 739 kg/trip. The catch rate peaked again at 911 kg/trip during the 2004-05 fishing season and since then remained at higher level above 827 kg/trip (Table 1; Figure 7).

For the dive fishery, the number of fishing trips showed an increasing trend from 1999 to 2005, but has been variable in recent years (Table 1). The total number of dive trips per season varied between 661 and 979. The highest numbers of fishing trips were recorded during 2004-05 (979 trips) and during 2007-08 (909 trips).

For the drag fishery since the 1991-92 fishing season, the seasonal CPUE has fluctuated from a low of 593 kg/trip during 1994-95 to a peak of 1,016 kg/trip during 2004-05 (Table 1; Figure 7). Since the 2004-05 fishing season, the CPUE has remained relatively stable at over 900 kg/trip. For drag licences, the number of trips has declined from 325 during the 1996-97 fishing year to 88 during 2003-04 and has been increasing since.

The average weekly catch rates fluctuated throughout each fishing season (Figures 8 and 9). However, there was no evident trend in the weekly catch rate within each fishing season for both the diving and dragging operations.

The largest difference between draggers and divers is the number of days they can fish. The dragging industry has seasonal restrictions on dragging. However, even though there is only 4 drag licence compared to 14 dive licences, during the 2007-08 season, the seasonal average number of trips per dive licences (65 trips) and drag licences (67 trips) were similar. Divers are limited to calmer periods of weather and locations.

CPUE has elements of population abundance, but is influenced by discarding due to product quality and market prices. Therefore, the CPUE series must be interpreted with caution, and cannot be used exclusively as an indicator of population abundance.

4.2 DIVER BASED SURVEYS

During July, August, and September of 2002, 31 commercial vessel days were volunteered and 83 dive transects were completed. Of these, 50 dive transects were completed along the New Brunswick coastline in the Maces Bay area, where no previous survey had been done (Figure 5). Another 11 dive transects were completed around Deer Island, and the remaining 22 dive transects were done around Campobello Island at the same locations as during the 1992-93 urchin survey (Figures 2 and 3; Tables 2 and 3).

During July, August, and September of 2003, 23 commercial vessel days were volunteered and 65 dive transects were completed. Of these, 36 dive transects were completed along the coast between Letete Passage and Pocologan, and 29 dive transects were completed around Deer Island at the same locations as during the 1993-94 urchin survey (Figures 3 and 4; Table 2).

In summary, 98 dive transects were completed during July, August, and September of 2002-03, in the 3 fishing areas that were surveyed in 1992-94 (Figures 2, 3, and 4; Table 2) and an additional 50 transects were completed in the expansion area of Maces Bay (Figure 5; Table 3). Due to budget constraint and time limitation, approximately half of the 200 dive transects previously surveyed in 1992-94 were resurveyed in 2002-03. Only data from locations resurveyed in 2002-03 were compared with the corresponding locations surveyed in 1992-94.

4.3. CAMPOBELLO ISLAND SURVEY (1992 VERSUS 2002)

During 2002, around Campobello Island, 9 locations (1, 2, 3, 4, 5, 7, 14, 15, and 16) were resurveyed out of 16 locations that were previously surveyed in 1992, (Figure 2; Table 2). The 9 locations represented approximately 65% of the overall fishable bottom area surveyed in 1992. Of these 9 locations revisited in 2002, 3 locations (1, 2, and 5) were only partially (50%) resurveyed. However, for comparison between 1992 and 2002, all 9 locations were included in the analysis. The total fishable bottom area of the 9 locations was 9.4 km^2, of which 5.4 km^2 were within the 0 to 10 m depth strata and 4.0 km^2 were between 11 and 20 m (Tables 4A to 10).

4.3.1. Size Structure

The proportion of legal size urchins ($\geq$ 51 mm TD) was generally lower in both depth strata during 2002 in comparison to 1992 (Figure 10; Table 4A). The proportions of fishable urchins showed in Table 4A are weighted by the bottom area (m^2) of each location and those in Figure 10 are not. Therefore, the estimated percentages of fishable urchins in Table 4A are lower and provided a more realistic picture of the overall proportion of legal size urchins for each location and fishing area.

During 1992 and 2002, the size distribution of sea urchins varied among locations and between the shallow (0 to 10 m) and deeper strata (11 to 20 m), (Figure 10; Table 4A). During the 1992 and 2002 surveys, the overall percentage of legal size sea urchins ($\geq$ 51 mm TD) was higher (17% and 13%, respectively) in shallow water in comparison to deeper water (2% and 7%, respectively). The proportion of legal size sea urchins in the 0 to 10 m depth strata was higher

(17%) in 1992 than in 2002 (13%). This is in contrast to the proportion of legal size sea urchins in deeper water (10 to 20 m), which was lower (2%) in 1992 than in 2002 (7%), (Figure 10; Table 4A).

There was no mode to distinguish age classes. However, the proportion of sub-legal size sea urchins (25 to 50 mm TD) was higher (76%) in 2002 than in 1992 (65%) in the 0 to 10 m depth strata, and was lower during 2002 (52%) in deeper water compared to 1992 (56%), (Table 4A). The proportion of immature sea urchins (< 25 mm TD) was lower in 2002 (12%) compared to 1992 (18%) in shallow water, and was similar for both survey periods (41% and 42%) at depths of > 10 m. The proportion of immature sea urchins was much larger in the deeper strata (>10 m) during both survey periods.

4.3.2. Density

Off Campobello Island, in 1992 and 2002, the density of sea urchin (all size combined) was 14.7 and 26.0 urchins/m^2, respectively, in the 0 to 10 m depth strata, and 15.6 and 10.2 urchins/m^2, respectively, in the 11 to 20 m depth strata (Table 4A). However, due to the high variability in sea urchin densities between locations, there was no significant difference in the overall sea urchin densities between the 2 survey periods and between depth strata (Tables 4B and 4C). During 2002, the density of sea urchins (all size combined) within each location was always higher in the 0 to 10 m depth strata.

During both survey periods, the highest densities of sea urchins (all size combined) were located off the northern end of Campobello Island at locations 1, 2, 15, and 16, and southern end at locations 4 and 5 (Figure 2; Tables 4A to 10). The overall densities for these same 6 locations, in the 0 to 10 m depth stratum, ranged between 17 and 40 urchins/m^2 (average 27 urchins/m^2) during 1992, and ranged between 23 and 83 urchins/m^2 (average 46 urchins/m^2) during 2002. The most notable increase in sea urchin density occurred in adjacent locations 1 and 15. In location 1, in the 0 to 10 m stratum, the density of sea urchins increased from 40 urchins/m^2 during 1992 to 71 urchins/m^2 in 2002, and in location 15 the density increased from 25 to 83 urchins/m^2. Low densities, which ranged between 0 and 1 urchin/m^2 during 1992 and 0 and 3 urchins/m^2 in 2002, were found at locations 3 and 14 (Figure 2 and Tables 4A).

The density of legal size sea urchins (≥ 51 mm TD) was significantly higher in the shallow depth (0 – 10 m) strata in comparison to the deeper stratum (> 10 m) (Table 4C). During 1992 and 2002 surveys, the overall density of legal size sea urchins (≥ 51 mm TD) was 2.5 and 3.2 urchins/m^2, respectively, in shallow water in comparison to 0.3 and 0.7 urchin/m^2 respectively, in deeper water (Table 4A). However, due to the high variability in the density of sea urchins between locations there was no significant difference in the overall legal size urchin densities between the 1992 and 2002 survey periods (Table 4B). The highest increases in legal size sea urchins occurred in locations 2, 5, 15, and 16 (Figure 2; Table 4A).

There were no significant differences in the overall densities of sub-legal size sea urchins (25 to 50 mm TD) between the 1992 and 2002 survey periods and between depth strata (Tables 4B and 4C). In the 0 to 10 m depth stratum the density of sub-legal size sea urchins was 19.9 urchins/m^2 in 2002 compared to 9.5 urchins/m^2 in 1992 (Table 4A). In deeper water > 10 m the density of sub-legal size sea urchins was 5.3 urchins/m^2 in 2002 compared to 8.8 urchins/m^2 in 1992.

There were no significant differences in the overall densities of immature sea urchins (< 25 mm TD) between the 2 survey periods and between depth strata (Tables 4B and 4C). The only

exception was during the 1992 survey when the density of immature sea urchin was significantly higher in the deeper depth stratum. The density of immature sea urchins in the 0 to 10 m depth stratum was 3.0 urchins/m^2 in 2002 compared to 2.6 urchins/m^2 in 1992 and in deeper water > 10 m was 4.2 urchins/m^2 in 2002 compared to 6.6 urchins/m^2 in 1992 (Table 4A).

4.3.3. Biomass

During 2002, the overall fishable biomass for the Campobello Island fishing area, was estimated at 1,240 t, compared to 1,014 t in 1992 (Tables 5 to 10; Appendixes 2 to 5). This represented an increase of approximately 22% since 1992. This increase in legal biomass occurred in both the 0 to 10 m depth stratum and in the 11 to 20 m depth stratum. The legal size biomass in the shallow water (0 – 10 m) increased by 13%; from 938 t during 1992 to 1,063 t during 2002. In the deeper water (11 to 20 m), the legal size biomass increased by 133%; from 76 t in 1992 to 177 t in 2002 (Tables 5 to 10). Most of the legal size biomass increase occurred in the northern part of Campobello Island (locations 1, 2, 15, and 16) and in location 5 on the southern end (Figure 2).

4.4. DEER ISLAND SURVEY (1992-93 VERSUS 2002-03)

During the 2002-03 survey, only 9 locations (18, 19, 20, 24, 25, 29, 30, 31, 32) out of the 18 locations that were previously surveyed around Deer Island in 1992-93, were resurveyed (Figure 3; Table 2). These 9 locations included most of the eastern part of Deer Island and several smaller adjacent islands on the eastern side of Deer Island and represented 50% of the overall fishable bottom areas surveyed in 1992-93 (Figure 3). The total fishable bottom area of the 9 locations was 10.7 km^2, of which 6.7 km^2 were within the 0 to 10 m depth strata and 4.0 km^2 were within the 11 to 20 m depth strata (Tables 5 to 10).

4.4.1. Size Structure

Around Deer Island and the surrounding islands, the size distribution of sea urchins varied among locations and between the shallow (0 to 10 m) and deeper depth strata (11 to 20 m) (Figure 10; Table 4A). The proportions of fishable sea urchins showed in Table 4A are weighted by the bottom area (m^2) represented in each location and those in Figure 10 are not. Therefore, as previously mentioned, the estimated percentages of fishable sea urchins in Table 4A are lower, and provided a more realistic picture of the overall proportion of legal size sea urchins for each location and fishing area.

During the 1992-93 and 2002-03 survey periods, the overall percentage of legal size sea urchins (≥ 51 mm TD) was higher (13% and 8%, respectively) in the shallow stratum (0 to 10 m) in comparison to the deeper stratum (7% and 6%, respectively) (Table 4A). The percentage of legal size sea urchins was lower during 2002-03 (7%) compared to 1992-93 (12%) (Tables 7 and 10).

There was no mode to distinguish age classes. However, the proportion of sub-legal size sea urchins (25 to 50 mm TD) was higher in 2002-03 than in 1992-93 in the 0 to 10 m depth stratum (76% compared to 65%) and similar in the deeper stratum (52% compared to 56%). (Figure 10; Table 4A). The proportion of immature sea urchins (< 25 mm TD) was lower in 2002-03 (12%) compared to 1992-93 (18%) in the shallow stratum and was similar in the deeper stratum (>10 m) (41% compared to 42%). The proportion of immature sea urchins was much larger in the deeper stratum (>10 m) during both survey periods.

4.4.2. Density

Off Deer Island, due to the high variability in sea urchin densities (all size combined) between locations, there was no significant difference in the overall sea urchin densities between the 1992-93 and 2002-03 survey periods (Figure 3; Tables 4A and 4B). The overall density of sea urchins was 34.7 urchins/m^2 in 1992-93 and 24.9 urchins/m^2 during 2002-03. The overall densities at each location ranged between 29 and 55 urchins/m^2 during 1992-93, and between 6 and 39 urchins/m^2 during 2002-03.

The density of sea urchins (all size combined) was significantly higher in the 0 to 10 m depth stratum during the 1992-93 and 2002-03 survey periods (Table 4C). The overall density of sea urchins in the 0 to 10 m depth stratum during 1992-93 was 42.0 urchins/m^2 and 32.2 urchins/m^2 during 2002-03. In the 10 to 20 m depth stratum, the overall density of sea urchins was 22.5 urchins/m^2 during 1992-93 and 12.6 urchins/m^2 during 2002-03 (Table 4A).

The density of legal size sea urchins ($\geq$ 51 mm TD) was significantly lower during 2002-03 than in 1992-93 in the 0 to 10 m depth stratum (2.4 urchins/m^2 compared to 5.5 urchins/m^2) and when both depth strata were combined (1.8 urchins/m^2 compared to 4.0 urchins/m^2) (Tables 4A and 4B). Although the overall density of legal size sea urchins in the deeper water was also lower in 2002-03 (0.7 urchin/m^2) than in 1992-94 (1.5 urchins/m^2) there was no significant difference in density of sea urchins between the 2 survey periods. The highest decreases in the density of legal size sea urchins occurred in locations 18, 19, 24, 29, 30, 31 and 32 (Figure 3; Table 4). The density of legal size sea urchins ($\geq$ 51 mm TD) was significantly higher in the shallow depth strata during both survey periods (Table 4C)

The density of sub-legal size sea urchins (25 to 50 mm TD) was not significantly different between the 2 survey periods, both in the 0 to 10 m depth stratum (23.8 urchins/m^2 in 2002 compared to 26.2 urchins/m^2 in 1992-93) and in the deeper stratum (7.0 urchins/m^2 in 2002 compared to 10.2 urchins/m^2 in 1992-93), (Table 4A and 4B). However, the density of sub-legal size sea urchins was significantly higher in the shallow depth stratum during both survey periods (Table 4C).

The density of immature sea urchins (< 25 mm TD) was not significantly different between 2002 (6.0 urchins/m^2) and 1992 (10.2 urchins/m^2) in the 0 to 10 m depth stratum, but was significantly lower in deeper water > 10 m and when all depths were combined during 2002 (4.5 and 5.5 urchins/m^2, respectively) in comparison to 1992-93 (10.8 and 10.4 urchins/m^2, respectively), (Tables 4A and 4B). During 1992-93 and 2002, the density of immature sea urchins was not significantly different between the shallow and deeper stratum (10.2 and 10.8 urchins/m^2, respectively) during 1992-93 and during 2002 (6.0 and 4.5 urchins/m^2, respectively), (Tables 4A and 4C).

4.4.3. Biomass

During 1992-93, the overall fishable biomass off Deer Island was estimated at 2,965 t, compared to 1,200 t in 2002-03 (Tables 5 to 10; Appendixes 6 to 9). This represents a decrease of approximately 60% since 1992-93. This decrease in fishable biomass occurred both in the 0 to 10 m depth range and in the 11 to 20 m depth stratum. The fishable biomass, in the shallow water (0 –10 m) decreased by 60%; from 2,538 t during 1992-93 to 1020 t during 2002. In the deeper water (11 to 20 m), the fishable biomass decreased by 58%; from 427 t in 1992-93 to 179 t in 2002 (Tables 5 to 10; Appendixes 6 to 9).

4.5. LETETE TO POCOLOGAN SURVEY (1993-94 VERSUS 2003)

During the 2003 survey, only 10 locations were surveyed (35, 36, 37 38, 43, 45, 46, 48, 53, 54) out of the 20 locations that were previously surveyed along the coastline between Letete and Pocologan in 1993-94 (Figure 4; Table 2). Locations 35, 36, 37, 38, 43, 45, 46, and 48 were located on the west end of this coastal area in the Letete and Letang area and locations 53 and 54 were located at the east end near Pocologan (Figure 4). These 10 locations represented approximately 54% of the overall fishable bottom area surveyed in 1993-94. The total fishable bottom area of the 10 locations was 16.8 square kilometres (km^2), of which 11.2 km^2 were within the 0 to 10 m depth stratum and 5.7 km^2 were between 11 and 20 m (Tables 5 to 10).

4.5.1. Size Structure

The proportions of fishable sea urchins showed in Table 4A are weighted by the bottom area (m^2) represented in each location and those in Figure 11 are not. Therefore, as previously mentioned the estimated percentages of fishable sea urchins in Table 4A are lower and more representative of the overall proportion of legal size sea urchins than those showed in Figure 11. The proportion of legal size sea urchins in both depth strata was 12% and 6% during 2003 and 15% and 8% during 1993-94 (Table 4A). Similarly to Campobello and Deer islands, the overall percentage of legal size urchins ($\geq$ 51 mm TD) was higher (15% in 1993-94 compared to 12 % in 2002-03) in shallow water in comparison to deeper water (8% and 6%, respectively) (Figure 11; Table 4A).

As in the other areas, there was no mode to distinguish age classes. However, the proportion of sub-legal size sea urchins (25 to 50 mm TD) was higher in 2003 than in 1993-94 in the 0 to 10 m depth strata (64% compared to 55%) and lower in deeper water (35% compared to 56%), (Table 4A). The proportion of immature sea urchins (< 25 mm TD) was lower in 2003 (24%) compared to 1993-94 (30%) in shallow water and was higher during 2003 in the deeper stratum (>10 m) (59% compared to 35%). The proportion of immature sea urchins was higher in the shallow stratum (0 to10 m) during 1993-94 (35% compared to 30%) and lower in the shallow water during 2003 (24 % compared to 59%).

4.5.2. Density

Along the coastal area of Letete to Pocologan, due to the high variability in sea urchin densities between locations, there was no significant difference in the overall sea urchin densities (all sizes combined) between the 2 survey periods and in both depth strata (Figure 4; Tables 4A and 4B). The overall density of sea urchins (all sizes combined), varied between 26.5 and 16.6 urchins/m^2 in the 1993-94 survey compared to 27.8 and 8.5 urchins/m^2 during the 2003 survey period, in the shallow and deep strata, respectively. During both surveys, the highest densities occurred at location 35 and the lowest at locations 37 and 54. Although the densities of sea urchins were generally higher in the shallow depth stratum, there was no significant difference in the densities of sea urchins between depth strata during both survey periods (Table 4C).

Due to the high variability in sea urchin densities between locations there was no significant difference in the densities of legal size sea urchins ($\geq$ 51 mm TD) between the 2 survey periods in both depth strata (Tables 4A and 4B). During the 1993-94 and 2003 surveys, the overall density of legal size sea urchins was 4.0 and 3.3 urchins/m^2, respectively, in shallow water in comparison to 1.4 and 0.5 urchins/m^2, respectively, in deeper water (Table 4A). The highest decreases in legal size sea urchins occurred in locations 35 and 36, near Letete (9.3 and

4.8 urchins/m^2 in 1993-94 compared to 2.4 and 1.1 urchins/m^2, respectively, during 2003), (Figure 4; Table 4). In contrast, there was a notable increase in the density of legal size sea urchin in location 54 near Pocologan (0.2 urchins/m^2 in 1993-94 compared to 2.6 urchins/m^2 in 2003). The densities of legal size sea urchins were significantly higher in the shallow depth stratum during both survey periods (Table 4C).

There was no significant difference in the densities of sub-legal size sea urchins (25 to 50 mm TD) between the 1993-94 and 2003 survey periods in both depth strata (Tables 4A and 4B). The overall density of sub-legal size sea urchins in the 0 to 10 m depth stratum during 2003 was 17.9 urchins/m^2 compared to 14.5 urchins/m^2 in 1993-94, and in deeper water was 3.0 urchins/m^2 during 2003 compared to 9.3 urchins/m^2 in 1993-94. The density of sub-legal size sea urchins was significantly higher in the shallow depth stratum during 2002-03, but was not significantly different between depth strata during the 1993-94 survey period (Table 4C).

The density of immature sea urchins (< 25 mm TD) was not significantly different between the 1993-94 and 2003 survey periods in both depth strata (Tables 4A and 4B). The density of immature sea urchins in the 0 to 10 m depth stratum was 8.0 urchins/m^2 during 1993-94 compared to 6.6 urchins/m^2 in 2003. In the deeper water > 10 m, the density of immature urchins was 5.9 urchins/m^2 during 1993-94 compared to 5.0 urchins/m^2 in 2003. The density of immature sea urchins was not significantly different between depth strata during both survey periods (Table 4C).

4.5.3. Biomass

The overall fishable biomass for the Letete fishing area was estimated at 2,631 t during 2003 compared to 3,721 t in 1993-94 (Figure 4; Tables 5 to 10). This represented a decrease of approximately 29% since 1993-94. This decrease in legal biomass also occurred in the 0 to 10 m depth range and in the 11 to 20 m depth stratum. The legal biomass in the shallow water (0 – 10 m) decreased by 23% or from 3,128 t during 1993-94 to 2,412 t during 2003. In the deeper water (11 to 20 m) the legal biomass decreased by 63% or from 593 t in 1993-94 to 218 t in 2003 (Tables 5 to 10; Appendixes 10 to 13).

4.6. MACES BAY SURVEY (2002)

The Maces Bay area was surveyed for the first time during August and September 2002 (Figure 5). Eleven new locations (55 to 65) were surveyed (Table 3). The total fishable bottom area was estimated at 16.4 km^2. Most of the fishable bottom (13.3 km^2) was located on shallow bottom of less than 10 m (Figure 5; Table 3).

4.6.1. Size Structure

The proportions of fishable sea urchins showed in Table 4A are weighted by the bottom area (m^2) represented in each location and those in Figures 11 are not. Therefore, as previously mentioned, the estimated percentages of fishable sea urchins in Table 4A are lower and more representative of the overall proportion of legal size urchins than those showed in Figure 11. The overall percentage of legal size sea urchins ($\geq$ 51 mm TD) was lower (22%) in the 0 to 10 m depth stratum in comparison to deeper water > 10 m (28%), (Figure 11; Table 4A). The proportion of sub-legal size sea urchins (25 to 50 mm TD) was 58% in the 0 to 10 m depth strata compared to 49% in deeper water. The proportion of immature sea urchins (< 25 mm TD) was 20% in shallow water and 23% in deeper water.

4.6.2. Density

In the Maces Bay coastal area, the overall density of sea urchins (all sizes combined) was 10.3 urchins/m^2 (Figure 5; Table 4A). The highest densities of sea urchins occurred at locations 59 (25 urchins/m^2) and 60 (27 urchins/m^2). In all the other locations, the densities of sea urchins were less than 13 urchins/m^2. Although the overall sea urchin density was higher in the shallow depth stratum (0 to 10 m) (12.1 urchins/m^2 compared to 2.8 urchins/m^2 in the 11 to 20 m depth strata), the density of sea urchins was not significantly different between depth strata (Tables 4A and 4C).

Even though the overall density of legal size sea urchins (≥ 51 mm TD) was more than 3 times higher (2.7 urchins/m^2) in the shallow depth stratum (0 to 10 m) compared to the deeper bottom area > 10 m (0.8 urchin/m^2), there was no significant difference in the density of legal size sea urchins between depth strata (Tables 4A and 4C). The density of sub-legal and immature sea urchins was not significantly different between depth strata (Table 4C). The density of sub-legal size sea urchins was 7.0 urchins/m^2 in shallow water and 1.4 urchins/m^2 in the deeper stratum. The density of immature sea urchins (< 25 mm TD) was 2.4 urchins/m^2 in the shallow stratum and 0.6 urchin/m^2 in deeper water > 10 m (Table 4A).

4.6.3. Biomass

The estimated legal biomass for the Maces Bay area was 2,706 t (Table 11; Appendixes 14 and 15). The estimated legal biomass was mostly located in the shallow depth stratum (2,510 t in the 0 - 10 m stratum compared to 196 t in the deeper water).

4.7. OVERALL BIOMASS ESTIMATE

During 2002-03, the fishable biomass was re-evaluated using the corresponding resurvey locations as in the 1992-94 survey (Tables 12 and 13). Consequently, the revised estimate of the fishable biomass for the 1992-94 survey was 7,700 t. In comparison, for the corresponding locations in the 2002-03 survey the biomass was estimated at 5,071 t a decreased of 34%.

During the 2002-03 survey, an additional sea urchin fishing area between Maces Bay and Chance Harbour was surveyed. An additional 2,706 t of legal size urchins was estimated for this relatively new fishing area, which was not included in 1996 when the original TAC was established (Table 13). Therefore, the total legal biomass for all the fishing areas surveyed during 2002-03, including Maces Bay, was estimated at 7,777 t.

Assuming a decline of 34% of the overall legal biomass of 13,245 t that was estimated for all the fishing areas surveyed during 1992-94, the revised fishable biomass was estimated to have decline to 8,742 t (Robinson and MacIntyre 1993, 1995; DFO 1996, 2000) (Table 12). By adding the 2,706 t of fishable biomass from the Maces Bay area, a total fishable biomass of 11,448 t was estimated. Based on the established TAC of 900 t, the harvesting rate was estimated to be 7.9% - 1.1% higher than the harvesting rate of 6.8% that was approved in 1996.

5. ROE QUALITY

Sea urchin roe quality expressed as proportion of marketable roe prior to the opening of the fishery provides an indication of quality later in the year and may be important in the management of the fishery. At this time, data on roe quality from the July to September period is only available from surveys.

The 2002-03 survey provided new information on the stage of gonads development. In order to compare this data with roe quality data previously collected during the 1992-93 surveys, only data that came from the same locations and season were used in the analysis. Data from July, August, and September 1992-93 and 2002-03 were compared in the analysis (Figures 12 and 13).

Based on survey data, roe quality had improved during 2002-03 in comparison to 1992-93, which is consistent with anecdotal information from the fishery. However, no data are available for the intervening years. During the July-September 1992-93 survey periods, few Grade A and B roe were found in comparison to the 2002-03 period (Figure 12). Off Campobello Island, the proportion of marketable roe had increased from 48% in 1992-93 to 66% in 2002-03 (Figure 13). Off Dear Island and Letete, the proportion of marketable urchins increased from 61% and 47%, respectively, in 1992-93 to 75% for both areas in 2002-03. In the Maces Bay area, the proportion of marketable urchins was 67% (Figures 12 and 13).

During 1992-93 the proportion of marketable sea urchins was much higher in the shallow depth stratum (0 -10 m) off Campobello and Deer islands (51% and 66% in shallow depth compared to 17% and 33% in deeper depth) (Figures 12 and 13) Off Letete, the proportion of marketable urchins was similar between depth strata (46% and 49%). During 2002-03, the proportions of marketable urchins were also higher in the shallow depth strata (ranged between 67% and 78%). However, the proportion of marketable urchins in the deeper strata had increased substantially since 1992-93 and ranged between 58% and 71% (Figure 13).

6. AGE STRUCTURE

Robinson and MacIntyre (1997) have demonstrated that growth rings in the test of the green sea urchin can easily be revealed and that the lines appear to have an annual periodicity. They also showed that the wild populations of sea urchins throughout the southwestern New Brunswick area differ in their size and age distributions and, in some areas, could be up to 25 years old. Their results showed a great deal of variation in the age at a particular size, suggesting the animals were limited in their growth potential, probably through lack of food. For example, a 20 mm sea urchin could be between 2 and 10 years old, while a 50 mm sea urchin could range from 4 to almost 25 years (Robinson and MacIntyre 1997).

Urchin size is a poor indicator of age. This explains why the size-frequency distributions may not be particularly helpful in separating year-classes. While some locations have very poor growth, there are others that seem to have fast growing sea urchins. Some of the difference between the sites may be due to fishing activity reducing the densities of larger sea urchins. Their results suggest that if sufficient food is available, then the sea urchins are capable of responding to the increased resources (Robinson and MacIntyre 1997). However, size age data collected during 2002 in areas that have been heavily fished for at least a decade shows similar variability in age at size (Figure 14). In these areas, we can assume that food is not a limiting factor for growth since a large proportion of legal size urchins are removed every year, giving the smaller urchins

more space and food to grow. The variability in the age at size increases proportionally with larger size urchin suggesting that maybe there could be a problem with the ageing technique used in the ageing of older urchins. A sample where only large urchins were aged, taken in the Deer Island fishing area, showed negative growth (Figure 14). However, in all areas sampled there are large animals that are younger than some of the smaller animals in the sample. Thus, the Deer Island sample results could just be a sampling issue or could reflect a recent change in the environment/habitat/food supply that resulted in faster growth and younger animals overtaking the older animals there before the change.

7. CONCLUSIONS AND ADVICE

There has been an increasing trend over time in CPUE for both the dive and drag fisheries since 1991-92 (Figure 7). Catch rates based on both sea urchin dragger and diver logbooks have been the highest during the last 4 fishing seasons since 1996. However, CPUE has elements of population abundance, but is influenced by discarding due to product quality, yield, and market prices. Therefore, the CPUE series must be interpreted with caution, and cannot be used exclusively as an indicator of population abundance. Implementation of the new logbook format will facilitate collection and analysis of effort and harvesting rate data allowing the fishery to be more closely monitored on a timelier basis.

With the exception of Deer Island, where legal size sea urchin (≥ 51 mm TD) densities have significantly decreased during 2002-03, all other areas show no significant differences in densities for each size grouping between the 2 survey periods. The density of legal size and sub-legal size urchins was significantly higher in the shallow strata (< 10 m) during both survey periods and within each fishing area compared to the deeper strata (10 – 20 m). Survey designs biases may have been introduced because survey transect locations were not re-randomized for the most recent surveys (Waddell et al. 2003). Only 2 surveys are available, and are 10 years apart, and do not provide a time series to interpret biological characteristics.

Total biomass has changed little between the 2 survey periods. However, the estimated fishable biomass appears to have declined. Based on the established TAC of 900 t, the harvesting rate is estimated to be 7.9% - 1.1% higher than the harvesting rate of 6.8% that was approved in 1996 (Robinson and MacIntyre 1993, 1995; DFO 1996; 2000). However, the Passamaquoddy Bay area is also fished but has never been surveyed; thus, no biomass estimate for this area is available. Therefore, the 7.9% harvesting rate is an overestimate.

The 2002-03 survey can be used as a benchmark for the LFA 36 sea urchin fishery. Even if we assume that the harvesting rate has been low, the overall legal biomass has nevertheless decreased over the last 10 years. For species that move little, there is a risk of serial depletion of the stock. This occurs when the highest densities are fished first. Some of the lower density areas may not have been harvested because they were uneconomical to fish. Therefore, it is possible that economic densities are more depleted than the total density. A cautionary approach should be taken and a low harvesting rate should be maintained to ensure the long-term sustainability of this sea urchin fishery.

The LFA 36 sea urchin fishery is mainly harvested by divers. Consequently any impact from dragging operation is greatly reduced. Although important quantities of sub-legal size sea urchins are harvested by divers and subsequently sorted and discarded on board the vessel, very little by-catch is harvested by divers and divers cause minimal disturbance on the bottom.

Fishery impacts on the ecosystem with respect to by-catch of non-urchin species and potential impact of urchin fishing on the habitat requires an approach to collect and process new information. There is a lack of information on indirect mortality due to interaction with drags and divers. Drag impacts on the benthos and the survival of culled and undersized urchins from the drag fishery is also unknown. Natural mortality is unknown. At present, there is no at-sea observer coverage, which limits quantification of by-catch amounts by the dragger fleet and the ability to evaluate ecosystem impacts of the fishery by both divers and draggers.

The diver based surveys are critical to the assessment of this resource and another survey including all fishing areas in LFA 36 is recommended in the next 2 to 3 years. Prior, to any new survey a review of the survey design is recommended.

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9. TABLES

Table 1. Lobster Fishing Area (LFA) 36 historical sea urchin landings and total allowable catch (TAC) in metric tons (t), the percentage of the season total landings for each fishery type, the catch rates in kilogram per trip (kg/trip) and effort in number of trips per season for dive and drag licenses by fishing season from 1989-90 to 2007-08. Missing data from earlier years are indicated as blank and the weight in kilograms came from available log information and was used for determining catch rate (kg/trip) and trip number.

Season	Dragging					Diving					Total	TAC
	Landings (t)	% of total	Kg used in analysis	# of trips	Kg per trip	Landings (t)	% of total	Kg used in analysis	# of trips	Kg per trip	(t)	(t)
1989-90											9	
1990-91											60	
1991-92					745					519	120	
1992-93					762					576	346	
1993-94					601					484	510	
1994-95					593					694	912	
1995-96					656					912	786	
1996-97	262	27%	250,981	325	772	710	73%	704,390	873	807	972	900
1997-98	261	35%	259,042	293	884	495	65%	486,456	817	595	756	900
1998-99	242	33%	240,241	270	890	484	67%	478,395	700	683	726	900
1999-00	180	29%	179,122	234	765	437	71%	430,764	661	652	617	900
2000-01	148	24%	147,732	207	714	470	76%	466,150	779	598	619	900
2001-02	114	18%	113,329	138	821	517	82%	511,318	749	683	630	900
2002-03	127	16%	125,569	139	903	656	84%	652,618	908	719	783	900
2003-04	85	12%	85,070	88	967	618	88%	616,702	835	739	703	900
2004-05	174	16%	173,684	171	1016	893	84%	892,055	979	911	1068	900
2005-06	109	13%	109,252	120	910	749	87%	747,595	856	873	858	900
2006-07	150	19%	149,718	151	992	635	81%	632,577	765	827	785	900
2007-08	263	26%	262,444	267	983	766	74%	764,093	909	841	1028	900

Table 2. The number of transects and the number of 10 m sections within each location that were surveyed during 1992-94 and 2002-03. Only locations with (*) were used for comparison between the 1992-94 and 2002-03 surveys.

Locations	1992-94			2002-03		
	Total bottom area fishable (m^2)	Total number of transects	Total number of sections	Total bottom area fishable (m^2)	Total number of transects	Total number of sections
1*	895.126	13	118	895.126	5	50
2*	2.571.785	10	132	2.571.785	5	64
3*	2.070.907	1	15	2.070.907	1	15
4*	735.881	1	15	735.881	2	23
5*	667.382	3	45	667.382	1	15
6	867.428	2	30			
7*	587.520	1	15	587.520	1	15
8	974.745	1	15			
9	731.594	2	30			
10	198.247	2	23			
11	551.833	4	49			
12	969.953	1	15			
13	799.910	4	38			
14*	1.341.035	2	27	1.341.035	2	27
15*	211.763	2	22	211.763	2	28
16*	290.597	3	36	290.597	3	36
Campobello	14,465,706	52	625	9,371,996	22	273
17	2.322.924	10	132		1	11
18*	1.240.253	4	60	1.240.253	4	53
19*	2.454.319	15	199	2.454.319	14	175
20*	1.152.311	4	41	1.152.311	2	16
21	830.722	3	29			
22	1.027.607	4	43			
23	1.576.032	2	21			
24*	1.214.401	8	76	1.214.401	6	58
25*	855.371	2	28	855.371	1	10
26	659.955	1	9			
27	573.697	1	6			
28	2.647.693	2	23			
29*	745.790	3	27	745.790	4	40
30*	1.222.773	5	59	1.222.773	5	53
31*	333.728	1	7	333.728	1	4
32*	1.469.825	3	25	1.469.825	2	17
33	396.556	4	42			
34	692.590	2	30			
Deer Is.	21,416,547	74	857	10,688,771	40	437
35*	1.300.620	6	69	1.300.620	5	52
36*	789.148	4	52	789.148	4	42
37*	1.208.335	4	40	1.208.335	4	38
38*	3.143.019	6	62	3.143.019	5	57
39	1.318.101	6	68			
40	482.135	1	15			
41	3.721.628	2	20			
42	650.557	4	36			
43*	482.051	2	24	482.051	1	8
44	1.951.746	1	15			
45*	621.045	5	60	621.045	3	25
46*	856.109	2	20	856.109	2	21
47	462.498	2	24			
48*	1.134.030	4	41	1.134.030	3	36
49	2.333.890	4	59			
50	1.410.054	6	81			
51	707.718	2	29			
52	1.430.861	4	32			
53*	3.881.472	7	105	3.881.472	7	101
54*	3.396.153	2	30	3.396.153	2	30
Letete	31,281,170	74	882	16,811,982	36	410
Total	67,163,423	200	2364	36,872,749	98	1120

Table 3. The number of transects and the number of 10 m sections within each location that were surveyed in the Maces Bay area during 2002.

Locations	1992-94			2002		
	Total bottom area fishable (m²)	Total number of transects	Total number of sections	Total bottom area fishable (m²)	Total number of transects	Total number of sections
55				1,124.797	2	30
56				755.659	1	15
57				1,247.928	3	43
58				1,406.703	1	15
59				2,651.297	9	130
60				1,399.227	6	90
61				2,414.085	11	164
62				2,028.461	7	102
63				991.107	3	45
64				1,146.867	5	66
65				1,278.721	2	30
Total				16,444.852	**50**	**730**

Table 4A. Mean densities (urchins/m²) and percentage of legal size urchins (≥ 51 mm test diameter (TD)), sub-legal (25 to 50 mm TD) and immature (< 25 mm TD) size urchins for each location during the 1992-94 and 2002-03 surveys.

Percent (1992-94 survey period) | Urchins/m² (1992-94 survey period)

Locations	Legals ≤10 m	Legals >10 m	Legals Total	Sub-Legals ≤10 m	Sub-Legals >10 m	Sub-Legals Total	Immatures ≤10 m	Immatures >10 m	Immatures Total	All Size ≤10 m	All Size >10 m	All Size Total	Legals ≤10 m	Legals >10 m	Legals Total	Sub-Legals ≤10 m	Sub-Legals >10 m	Sub-Legals Total	Immature ≤10 m	Immature >10 m	Immature Total
1	14	1	10	64	56	62	22	42	29	40	20	30	6	0	3	25	11	18	9	8	9
2	8	1	6	71	45	63	21	54	32	26	17	22	2	0	1	19	8	14	5	9	7
3																					
4	30	3	10	67	65	65	2	33	25	22	40	33	7	1	3	15	26	22	0	13	8
5	45	2	12	53	60	59	2	38	30	17	27	24	8	1	3	9	16	14	0	10	7
7	68		68	32		32	0		0	8		6	6		4	3		2	0		0
14	82		82	18		18	0		0	1.2	0	1	1	0	1	0	0	0	0	0	0
15	11	2	9	60	35	55	29	63	37	25	13	20	3	0	2	15	5	11	7	8	7
16	7	4	6	68	62	66	25	34	28	34	17	25	2	1	1	23	11	16	8	6	7
Campobello	**17.1**	**1.7**	**10.4**	**64.9**	**56.2**	**61.1**	**18.0**	**42.2**	**28.6**	**14.7**	**15.6**	**15.1**	**2.5**	**0.3**	**1.6**	**9.5**	**8.8**	**9.2**	**2.6**	**6.6**	**4.3**
18	11	0	11	64		64	25		25	40	0	29	4	0	3	26	0	19	10	0	7
19	43	40	43	54	49	53	3	11	4	7	2	6	3	1	3	4	1	3	0	0	0
20	4	4	4	74	57	70	22	39	26	43	18	32	2	1	1	32	10	22	10	7	8
24	18	18	18	66	44	60	17	37	22	49	32	43	9	6	8	32	14	26	8	12	10
25		6	2	56	50	54	43	44	43	66	37	55	0	2	1	37	18	30	28	16	24
28	11	3	8	52	53	52	37	44	40	59	45	53	6	1	4	31	24	28	22	20	21
30	15	2	13	54	38	51	31	60	36	58	21	44	9	1	6	31	8	22	18	13	16
31	18	11	15	78	42	65	5	47	20	58	28	42	10	3	6	45	12	27	3	13	8
32	15	4	12	69	39	59	15	58	29	78	31	52	12	1	6	54	12	31	12	18	15
Deer Is.	**13.1**	**6.6**	**11.5**	**62.5**	**45.5**	**58.4**	**24.3**	**47.9**	**30.0**	**42.0**	**22.5**	**34.7**	**6.5**	**1.5**	**4.0**	**26.2**	**10.2**	**20.3**	**10.2**	**10.8**	**10.4**
35	10	2	8	45	55	48	45	43	44	121	129	123	12	2	9	54	71	59	54	55	55
36	19	17	19	50	73	52	31	10	29	61	4	25	11	1	5	30	3	13	19	0	7
37	26	62	33	59	38	55	16	0	13	5	4	5	1	2	2	3	1	3	1	0	1
38	15	19	16	65	59	64	20	22	20	37	6	21	6	1	3	24	4	13	7	1	4
43	21	19	21	71	46	71	9	35	9	23	1	21	5	0	4	16	0	15	2	0	2
45	27	35	28	57	57	57	16	8	16	22	5	18	6	2	5	13	3	10	4	0	3
46	12	25	14	51	62	52	37	13	34	34	5	20	4	1	3	17	3	10	12	1	7
48	13	32	16	73	60	71	14	7	13	52	11	32	7	3	5	38	7	22	7	1	4
53	25	6	18	50	55	52	25	39	30	16	14	15	4	1	3	8	7	8	4	5	5
54	9	0	9	76		76	14		14	2		2	0		0	2		2	0		0
Letete	**18.0**	**8.4**	**13.4**	**54.9**	**56.1**	**55.2**	**30.2**	**38.3**	**31.4**	**26.5**	**16.6**	**23.2**	**4.0**	**1.4**	**3.1**	**14.5**	**9.3**	**12.8**	**8.0**	**5.9**	**7.3**
Grand Total	**14.5**	**6.1**	**12.2**	**58.3**	**52.3**	**57.4**	**26.2**	**41.6**	**30.4**	**28.2**	**18.0**	**24.4**	**4.1**	**1.2**	**3.0**	**16.7**	**9.4**	**14.0**	**7.4**	**7.5**	**7.4**

Percent (2002-03 survey period) | Urchins/m² (2002-03 survey period)

Locations	Legals ≤10 m	Legals >10 m	Legals Total	Sub-Legals ≤10 m	Sub-Legals >10 m	Sub-Legals Total	Immatures ≤10 m	Immatures >10 m	Immatures Total	All Size ≤10 m	All Size >10 m	All Size Total	Legals ≤10 m	Legals >10 m	Legals Total	Sub-Legals ≤10 m	Sub-Legals >10 m	Sub-Legals Total	Immature ≤10 m	Immature >10 m	Immature Total
1	8	1	6	79	49	68	13	49	27	71	45	58	6	1	3	56	22	40	9	22	16
2	10	17	11	82	46	78	8	37	11	41	7	27	4	1	3	34	3	21	3	3	3
3	26		26	25		25	48		48	0.3		0	0		0	0		0	0		0
4	13		13	67		67	19		19	23		9	3		1	16		6	4		2
5	29	14	23	70	79	74	0	7	3	49	15	26	14	2	6	34	12	19	0	1	1
7	25		25	73		73	2		2	25		19	6		5	18		14	1		0
14	13	14	13	84	83	84	4	3	4	3	5	3	0	1	0	2	4	2	0	0	0
15	6	0	6	57	6	48	37	94	47	83	32	65	5	0	3	47	2	31	31	30	30
16	13	4	9	59	49	55	28	47	36	31	18	24	4	1	2	18	9	13	9	8	9
Campobello	**12.1**	**6.8**	**10.9**	**76.2**	**51.8**	**70.8**	**11.5**	**41.1**	**18.1**	**26.0**	**10.2**	**19.4**	**3.2**	**0.7**	**2.1**	**19.9**	**5.3**	**13.7**	**3.0**	**4.2**	**3.5**
18	9		9	53		53	39		39	32	0	23	3	0	2	17	0	12	12	0	9
19	13	12	13	81	65	80	7	23	8	8	1	6	1	0	1	6	1	5	1	0	0
20	6	7	6	84	71	83	10	22	11	57	4	33	3	0	2	48	3	28	6	1	4
24	9	9	9	74	44	69	18	46	23	43	16	34	4	1	3	32	7	23	8	8	8
25	6		5	83		78	12		11	59	5	39	3	0	2	49	0	30	7	0	4
28	13	7	11	71	57	67	16	36	21	22	10	17	3	1	2	15	6	11	3	4	4
30	6	1	5	68	41	61	26	58	34	30	16	25	2	0	1	20	6	15	8	9	8
31	3	20	6	93	80	89	4	0	3	46	20	32	1	4	3	42	16	29	2	0	1
32	7	4	6	71	61	66	22	35	28	47	31	38	3	1	2	33	19	25	10	11	11
Deer Is.	**7.5**	**5.6**	**7.2**	**73.8**	**55.3**	**70.3**	**18.8**	**35.8**	**22.0**	**32.2**	**12.5**	**24.5**	**2.4**	**0.7**	**1.8**	**23.8**	**7.0**	**17.5**	**6.0**	**4.5**	**5.6**
35	4	0.7	3	69	33	56	27	67	41	75	97	82	3	1	2	52	32	46	20	65	33
36	10	0	9	77	31	70	13	69	22	30	3	13	3	0	1	23	1	9	4	2	3
37	17	45	21	82	54	77	1.0	1.0	1	1	0	1	0	0	0	1	0	0	0	0	0
38	14	36	15	64	45	63	22	19	22	22	1	11	3	0	2	14	1	7	5	0	2
43	7	6	7	84	89	84	9	5	9	60	4	54	4	0	4	50	4	46	5	0	5
45	8	23	9	82	56	80	10	21	11	57	13	46	4	3	4	46	~	37	6	3	5
46	9	0	9	69		68	22		22	50	0	26	5	0	2	34	0	18	11	0	6
48	8	27	10	62	41	59	30	33	30	54	9	31	4	2	3	33	4	18	16	3	9
53	18	0	18	48		48	33		33	26	0	15	5	0	3	13	0	7	9	0	5
54	25		25	51		51	23		23	10		10	3		3	5		5	2		2
Letete	**11.8**	**5.8**	**11.0**	**64.5**	**35.2**	**60.5**	**23.7**	**59.1**	**28.5**	**27.8**	**8.5**	**21.3**	**3.3**	**0.5**	**2.3**	**17.9**	**3.0**	**12.9**	**6.6**	**5.0**	**6.1**
Grand Total	**10.5**	**6.0**	**9.7**	**70.0**	**47.3**	**66.1**	**19.5**	**45.4**	**24.0**	**28.7**	**10.2**	**21.9**	**3.0**	**0.6**	**2.1**	**20.1**	**4.8**	**14.4**	**5.6**	**4.6**	**5.2**
55	22		22	73		73	5		5	4		3	1		0	3		2	0		0
56										0		0	0		0	0		0	0		0
57	24		24	66		66	10		10	13		13	3		3	9		9	1		1
58	27		27	19		19	54		54	0		0	0		0	0		0	0		0
59	22	19	22	59	28	58	19	53	20	35	2	25	8	0	6	20	1	15	7	1	5
60	8		9	53		53	38		38	27		27	2		2	15		15	10		10
61	28	19	26	59	58	59	13	23	15	11	12	11	3	2	3	7	7	7	1	3	2
62	49	48	49	47	47	47	4	5	4	6	3	5	3	1	2	3	1	2	0	0	0
63	35	44	35	63	50	63	2	7	2	7	0	4	2	0	1	4	0	2	0	0	0
64	53	47	52	45	51	46	2	2	2	3	2	2	1	1	1	1	1	1	0	0	0
65	36		36	56		56	8		8	1		1	0		0	1		0	0		0
Maces Bay	**22.1**	**28.1**	**22.4**	**57.8**	**48.1**	**57.4**	**20.0**	**22.6**	**20.2**	**12.1**	**2.8**	**10.3**	**2.7**	**0.8**	**2.3**	**7.0**	**1.4**	**5.9**	**2.4**	**0.6**	**2.1**

Table 4B. ANOVA analysis comparing the mean urchin densities (urchins/m²) between the 1992-94 and 2002-03 survey periods, for each fishing area, depth stratum, and size category. The cases, where the mean density is significantly different at p < .05, are indicated with an *.

Size Categories	Fishing Areas	Nb of Samples	Mean Urchins /m²	Standard Error	95% Lower	95% Upper	Nb of Samples	Mean Urchins /m²	Standard Error	95% Lower	95% Upper	F	*Significantly different at p < .05
		1992-94 Survey (Shallow ≤10 m)					2002-03 Survey (Shallow ≤10 m)						ANOVA
All sizes Combine	Campobello	9	19.2	4.7	8.5	30.0	9	36.3	9.4	14.7	57.8	2.6	0.123
	Deer Is.	9	50.9	6.7	35.4	66.4	9	38.2	5.6	25.4	51.0	2.1	0.165
	Letete	10	37.3	11.0	12.3	62.3	10	38.5	7.6	21.3	55.7	0.01	0.930
	Total	28	35.9	5.2	25.2	46.5	28	37.7	4.3	28.9	46.5	0.1	0.787
Legal ≥ 51 mm TD	Campobello	9	3.9	1.0	1.7	6.1	9	4.7	1.4	1.5	7.9	0.2	0.651
	Deer Is.	9	6.1	1.4	3.0	9.3	9	2.6	0.3	1.8	3.3	6.4	*0.023
	Letete	10	5.6	1.2	2.9	8.3	10	3.4	0.5	2.4	4.4	2.9	0.104
	Total	28	5.2	0.7	3.8	6.6	28	3.5	0.5	2.5	4.6	3.9	0.052
Sub-Legal 25-50 mm TD	Campobello	9	12.0	3.2	4.7	19.3	9	25.0	6.4	10.3	39.7	3.3	0.087
	Deer Is.	9	32.4	4.6	21.9	43.0	9	29.1	5.1	17.2	41.0	0.2	0.634
	Letete	10	20.5	5.2	8.8	32.2	10	27.1	5.9	13.7	40.5	0.7	0.412
	Total	28	21.6	2.9	15.6	27.6	28	27.1	3.3	20.4	33.8	1.5	0.219
Immature 5- 25 mm TD	Campobello	9	3.2	1.3	-0.2	6.3	9	6.3	3.3	-1.3	14.0	0.8	0.398
	Deer Is.	9	12.3	3.0	5.5	19.2	9	6.3	1.2	3.5	9.2	3.5	0.082
	Letete	10	11.0	5.1	-0.5	22.5	10	7.8	2.0	3.3	12.3	0.3	0.566
	Total	28	8.9	2.2	4.5	13.4	28	6.9	1.3	4.2	9.5	0.7	0.416
		1992-94 Survey (Deep 10-20 m)					2002-03 (Deep 10-20 m)						
All sizes Combine	Campobello	7	19.3	4.7	7.9	30.8	6	20.2	6.3	4.0	36.5	0.01	0.906
	Deer Is.	9	23.8	5.1	12.1	35.4	9	11.5	3.4	3.7	19.4	4.0	0.063
	Letete	9	19.8	13.7	-11.8	51.4	9	14.2	10.4	-9.9	38.3	0.1	0.753
	Total	25	21.1	5.2	10.3	31.9	24	14.7	4.3	5.9	23.6	0.9	0.356
Legal ≥ 51 mm TD	Campobello	8	0.4	0.1	0.0	0.7	9	0.6	0.2	0.0	1.1	0.7	0.415
	Deer Is.	9	1.7	0.6	0.3	3.1	9	0.9	0.4	-0.1	1.8	1.2	0.281
	Letete	9	1.5	0.3	0.8	2.3	9	0.8	0.4	-0.1	1.6	2.3	0.148
	Total	26	1.2	0.3	0.7	1.8	27	0.7	0.2	0.3	1.1	2.2	0.144
Sub-Legal 25-50 mm TD	Campobello	8	9.6	3.1	2.3	16.9	9	5.8	2.5	0.1	11.5	1.0	0.341
	Deer Is.	9	11.0	2.5	5.2	16.9	9	6.5	2.3	1.1	11.8	1.8	0.199
	Letete	9	11.0	7.5	-6.4	28.4	9	5.3	3.4	-2.5	13.2	0.5	0.503
	Total	26	10.6	2.8	4.8	16.4	27	5.9	1.5	2.7	9.0	2.2	0.140
Immature 5- 25 mm TD	Campobello	8	6.9	1.7	3.0	10.9	9	7.1	3.7	-1.5	15.7	0.0	0.967
	Deer Is.	9	11.0	2.4	5.5	16.5	9	3.6	1.5	0.2	7.1	6.8	*0.019
	Letete	9	7.2	6.1	-6.8	21.1	9	8.1	7.1	-8.3	24.6	0.0	0.919
	Total	26	8.4	2.3	3.8	13.1	27	6.3	2.6	0.9	11.7	0.4	0.544
		1992-94 Survey (All depth combine)					2002-03 Survey (All depth combine)						
All sizes Combine	Campobello	8	20.3	3.9	11.0	29.6	9	25.7	7.8	8.2	43.1	0.4	0.549
	Deer Is.	9	39.6	5.1	27.7	51.5	9	27.5	3.6	19.1	35.8	3.7	0.072
	Letete	10	28.1	10.9	3.3	52.8	10	28.9	7.9	11.1	46.8	0.0	0.950
	Total	27	29.6	4.6	20.0	39.1	28	27.4	3.8	19.7	35.1	0.1	0.716
Legal ≥ 51 mm TD	Campobello	8	2.3	0.4	1.3	3.3	9	2.7	0.7	1.2	4.2	0.2	0.689
	Deer Is.	9	4.2	0.8	2.3	6.1	9	2.0	0.2	1.5	2.5	7.0	*0.017
	Letete	10	3.9	0.8	2.1	5.7	10	2.4	0.4	1.6	3.3	2.7	0.116
	Total	27	3.5	0.4	2.6	4.4	28	2.4	0.3	1.8	2.9	5.6	*0.022
Sub-Legal 25-50 mm TD	Campobello	8	12.2	2.7	5.9	18.6	9	16.3	4.4	6.2	26.4	0.6	0.456
	Deer Is.	9	23.2	2.8	16.7	29.7	9	19.9	3.0	12.9	26.9	0.8	0.437
	Letete	10	15.5	5.2	3.7	27.3	10	19.4	5.4	7.1	31.7	0.3	0.613
	Total	27	17.1	2.4	12.2	22.0	28	18.5	2.5	13.4	23.7	0.2	0.677
Immature 5- 25 mm TD	Campobello	8	5.7	1.3	2.7	8.7	9	6.7	3.4	-1.2	14.6	0.1	0.792
	Deer Is.	9	12.2	2.5	6.5	17.8	9	5.4	1.2	2.6	8.2	6.0	*0.026
	Letete	10	8.7	5.2	-3.0	20.4	10	7.1	3.0	0.2	14.0	0.1	0.794
	Total	27	9.0	2.1	4.6	13.3	28	6.4	1.5	3.3	9.6	0.9	0.335

Table 4C. ANOVA analysis comparing the mean urchin densities (urchins/m^2) between the shallow depth stratum (< 10 m) and the deep stratum (10 – 20 m), for each fishing area, size category, and survey period. The cases, where the mean density is significantly different at p < .05 are indicated with an *.

Size Categories	Survey Period	Shallow (≤10 m)					Deep (10-20 m)					F	ANOVA *Significantly different at p < .05
		Nb of Samples	Mean Urchins /m²	Standard Error	95% Confidence limit Lower	Upper	Nb of Samples	Mean Urchins /m²	Standard Error	95% Confidence limit Lower	Upper		
All sizes Combine 1992-94	Campobello	9	19.2	4.7	8.5	29.9	7	19.3	4.7	7.9	30.8	0.0	0.993
	Deer Is.	9	50.9	6.7	35.4	66.4	9	23.8	5.1	12.1	35.4	10.4	*0.005
	Letete	10	37.3	11.0	12.3	62.3	9	19.8	13.7	-11.8	51.4	1.0	0.329
	Total	28	37.2	5.2	26.5	47.9	25	21.1	5.2	10.3	36.9	4.8	*0.034
All sizes Combine 2002-03	Campobello	9	36.3	9.4	14.7	57.8	6	20.2	6.3	4.0	36.5	1.6	0.228
	Deer Is.	9	38.2	5.6	25.4	51.1	9	11.5	3.4	3.7	19.4	16.7	*0.001
	Letete	10	38.5	7.6	21.3	55.7	9	14.2	10.4	-9.8	38.3	3.6	0.074
	Total	28	37.7	4.3	28.9	46.5	24	14.7	4.3	5.9	23.6	14.2	*0.000
	Maces Bay	11	9.7	3.4	2.1	17.4	5	3.7	2.1	-2.2	9.6	1.3	0.282
Legal ≥ 51 mm TD 1992-94	Campobello	9	3.9	1.0	1.7	6.1	7	0.4	0.1	0.7	0.7	9.9	*0.007
	Deer Is.	9	6.1	1.4	3.0	9.3	9	1.7	0.6	0.3	3.1	8.8	*0.010
	Letete	10	5.6	1.2	2.9	8.3	9	1.5	0.3	0.8	2.3	9.7	*0.006
	Total	28	5.4	0.7	4.0	6.8	25	1.3	0.3	0.7	1.8	29.8	*0.000
Legal ≥ 51 mm TD 2002-03	Campobello	9	4.7	1.4	1.5	7.9	6	0.9	0.3	0.2	1.6	4.8	*0.048
	Deer Is.	9	2.6	0.3	1.8	3.3	9	0.9	0.4	-0.1	1.8	9.7	*0.007
	Letete	10	3.4	0.5	2.4	4.4	9	0.8	0.4	-0.1	1.6	19.7	*0.000
	Total	28	3.5	0.5	2.5	4.6	24	0.8	0.2	0.4	1.3	22.4	*0.000
	Maces Bay	11	2.2	0.7	0.8	3.7	5	0.9	0.4	-0.1	2.0	1.6	0.229
Sub-Legal 25-50 mm TD 1992-94	Campobello	9	12.0	3.2	4.7	19.3	7	11.0	3.2	3.2	18.8	0.1	0.827
	Deer Is.	9	32.4	4.5	21.9	43.0	9	11.1	2.5	5.2	16.9	16.8	*0.001
	Letete	10	20.5	5.2	8.8	32.2	9	11.0	7.5	-6.3	28.4	1.1	0.306
	Total	28	22.4	2.9	16.4	28.4	25	11.0	2.9	5.1	16.9	7.6	*0.008
Sub-Legal 25-50 mm TD 2002-03	Campobello	9	25.0	6.4	10.3	39.7	6	8.6	3.1	0.6	16.7	3.9	0.071
	Deer Is.	9	29.1	5.1	17.2	41.0	9	6.5	2.3	1.1	11.8	16.2	*0.001
	Letete	10	27.1	5.9	13.7	40.5	9	5.3	3.4	-2.5	13.2	9.6	*0.007
	Total	28	27.1	3.3	20.4	33.8	24	6.5	1.7	3.1	10.1	28.2	*0.000
	Maces Bay	11	5.7	2.0	1.2	10.0	5	1.9	1.3	-1.6	5.5	1.4	0.254
Immature 5- 25 mm TD 1992-94	Campobello	9	3.2	1.3	0.2	6.3	7	7.9	1.6	4.1	11.8	5.3	*0.037
	Deer Is.	9	12.3	3.0	5.5	19.2	9	11.0	2.4	5.5	16.5	0.1	0.730
	Letete	10	11.0	5.1	-0.5	22.5	9	7.2	6.1	-6.8	21.1	0.2	0.633
	Total	28	9.3	2.2	4.7	13.8	25	8.8	2.3	3.9	13.5	0.0	0.877
Immature 5- 25 mm TD 2002-03	Campobello	9	6.3	3.3	-1.3	14.0	6	10.7	5.1	-2.3	23.7	0.6	0.464
	Deer Is.	9	6.3	1.2	3.5	9.2	9	3.6	1.5	0.2	7.1	2.0	0.181
	Letete	10	7.8	2.0	3.3	12.3	9	8.1	7.1	-8.3	24.6	0.0	0.962
	Total	28	6.9	1.3	4.2	9.5	24	7.1	2.9	1.0	13.2	0.0	0.941
	Maces Bay	11	1.9	1.0	-0.4	4.2	5	0.8	0.5	-0.7	2.2	0.4	0.517

Table 5. Summary of biomass calculations for Campobello, Deer Island, and Letete to Pocologan areas, during the 1992-94 surveys (depth of 0 to 10 m).

Locations	Area m²	No of Sections	Total number of urchins			Legal size urchins ≥ 51 mm TD			
			Mean #/m²	Number of Urchins	Biomass (t)	Percent (%)	Mean #/m²	Number of Urchins	Biomass (t)
1	453,568	65	39.6	17,940,359	468	14	5.5	2,497,193	165
2	1,503,081	98	25.6	38,491,911	873	8	2.2	3,232,643	206
3	1,096,689	15	0.0	0	0		0.0	0	0
4	285,868	14	22.2	6,348,312	245	30	6.7	1,914,570	124
5	213,676	28	17.5	3,737,041	193	45	7.9	1,697,261	125
7	443,237	15	8.5	3,748,308	232	68	5.7	2,535,040	185
14	1,149,266	21	1.2	1,327,129	100	82	0.9	1,081,898	91
15	137,725	18	24.5	3,375,028	77	11	2.6	356,551	23
16	132,589	26	33.8	4,475,134	91	7	2.3	304,080	19
Campobello	**5,415,699**	**300**	**14.7**	**79,443,219**	**2279**	**17**	**2.5**	**13,619,235**	**938**
18	909,150	49	40.0	36,355,795	869	11	4.3	3,942,479	253
19	1,815,680	153	7.4	13,361,269	693	43	3.2	5,760,867	454
20	635,923	18	43.4	27,614,956	566	4	1.7	1,092,310	70
24	807,432	47	48.8	39,388,079	1196	18	8.7	7,022,681	475
25	528,021	13	66.2	34,959,052	437	2	1.0	535,088	35
29	421,310	20	59.0	24,853,077	548	11	6.4	2,699,098	181
30	754,969	21	57.8	43,666,868	1134	15	8.8	6,652,117	449
31	158,681	1	57.5	9,124,158	294	18	10.2	1,621,043	99
32	668,448	10	77.8	51,998,570	1532	15	12.0	8,030,980	523
Deer Is.	**6,699,614**	**332**	**42.0**	**281,321,823**	**7,269**	**13**	**5.6**	**37,356,662**	**2,538**
35	916,123	52	120.9	110,759,278	2065	10	12.3	11,243,382	763
36	296,009	17	60.5	17,908,541	503	19	11.5	3,396,448	234
37	913,346	33	4.9	4,475,395	163	26	1.3	1,145,546	85
38	1,480,111	35	37.3	55,208,125	1579	15	5.7	8,390,872	582
43	431,145	7	23.1	9,959,453	354	21	4.8	2,049,074	146
45	469,486	17	22.1	10,375,645	365	27	6.0	2,836,598	222
46	439,760	9	33.7	14,819,904	320	12	4.1	1,816,447	125
48	567,150	15	52.2	29,605,245	781	13	6.9	3,914,230	258
53	2,247,236	84	15.8	35,506,334	1144	25	4.0	8,985,438	674
54	3,396,153	26	2.0	6,792,306	167	9	0.2	625,607	39
Letete	**11,156,519**	**295**	**26.5**	**295,410,226**	**7,438**	**15**	**4.0**	**44,403,642**	**3,128**
Grand Total	**23,271,832**	**927**	**28.2**	**656,175,268**	**16,987**	**15**	**4.1**	**95,379,539**	**6,603**

Table 6. Summary of biomass calculations for Campobello, Deer Island, and Letete to Pocologan areas, during the 1992-94 surveys (depth of 11 to 20 m).

Locations	Area m²	No of Sections	Total number of urchins			Legal size urchins ≥ 51 mm TD			
			Mean #/m²	Number of Urchins	Biomass (t)	Percent (%)	Mean #/m²	Number of Urchins	Biomass (t)
1	441,558	53	20.2	8,916,972	120	1.2	0.2	102,842	6
2	1,068,704	34	17.5	18,648,885	196	0.6	0.1	109,915	7
3	974,218								
4	450,013	1	40.2	18,090,523	265	2.6	1.0	467,858	40
5	453,706	17	27.1	12,314,115	185	2.1	0.6	253,030	15
7	144,283								
14	191,769	6	0.0	0	0		0.0	0	0
15	74,038	4	13.0	961,569	8	2.0	0.3	18,854	1
16	158,008	10	17.2	2,714,577	47	4.0	0.7	107,437	7
Campobello	**3,956,297**	**125**	**15.6**	**61,646,640**	**821**	**1.7**	**0.3**	**1,059,936**	**76**
18	331,103	11	0.1	31,605	0	0.0	0.0	0	0
19	638,639	46	1.6	996,832	46	40.1	0.6	400,179	31
20	516,388	23	18.1	9,366,829	152	3.5	0.6	329,818	22
24	406,969	29	32.4	13,167,552	337	18.2	5.9	2,400,335	190
25	327,350	15	36.6	11,967,916	205	5.9	2.2	707,615	46
29	324,480	7	45.0	14,592,329	179	3.0	1.4	444,888	29
30	467,804	31	21.4	10,029,869	104	2.3	0.5	234,960	17
31	175,047	6	27.8	4,866,307	88	10.8	3.0	524,798	35
32	801,377	15	30.9	24,730,494	301	3.6	1.1	881,800	57
Deer Is.	**3,989,157**	**183**	**22.5**	**89,749,734**	**1,412**	**6.6**	**1.5**	**5,924,393**	**427**
35	384,497	17	128.9	49,561,656	550	1.7	2.2	840,028	54
36	493,139	35	4.4	2,169,812	68	17.0	0.7	369,169	27
37	294,989	7	3.8	1,120,959	71	61.6	2.3	690,692	56
38	1,662,908	27	6.0	9,977,450	298	19.0	1.1	1,896,947	145
43	50,906	17	1.0	50,906	1	18.6	0.2	9,446	1
45	151,559	43	4.5	682,015	24	34.7	1.6	236,674	19
46	416,349	11	4.9	2,040,111	74	25.5	1.2	519,724	44
48	566,880	26	10.8	6,122,301	260	32.3	3.5	1,978,926	163
53	1,634,236	21	13.5	22,062,182	357	6.1	0.8	1,337,102	85
54	0	4	0.0	0	0	0.0	0.0	0	0
Letete	**5,655,463**	**208**	**16.6**	**93,787,391**	**1,703**	**8.4**	**1.4**	**7,878,709**	**593**
Grand Total	**13,600,917**	**516**	**18.0**	**245,183,765**	**3,936**	**6.1**	**1.1**	**14,863,038**	**1,097**

Table 7. Summary of biomass calculations for Campobello, Deer Island, and Letete to Pocologan areas, during the 1992-94 surveys (all depth combined).

Locations	Area m²	No of Sections	Total number of urchins			Legal size urchins ≥ 51 mm TD			
			Mean #/m²	Number of Urchins	Biomass (t)	Percent (%)	Mean #/m²	Number of Urchins	Biomass (t)
1	895,126	118	30.0	26,857,331	589	10	2.9	2,600,034	171
2	2,571,785	132	22.2	57,140,795	1068	6	1.3	3,342,558	214
3	2,070,907	15	0.0	0	0	0	0.0	0	0
4	735,881	15	33.2	24,438,834	510	10	3.2	2,382,428	164
5	667,382	45	24.1	16,051,155	378	12	2.9	1,950,290	140
7	587,520	15	6.4	3,748,308	232	68	4.3	2,535,040	185
14	1,341,035	27	1.0	1,327,129	100	82	0.8	1,081,898	91
15	211,763	22	20.5	4,336,596	85	9	1.8	375,406	24
16	290,597	36	24.7	7,189,711	138	6	1.4	411,517	26
Campobello	**9,371,996**	**425**	**15.1**	**141,089,859**	**3100**	**10**	**1.6**	**14,679,171**	**1,014**
18	1,240,253	60	29.3	36,387,401	869	11	3.2	3,942,479	253
19	2,454,319	199	5.9	14,358,101	740	43	2.5	6,161,046	485
20	1,152,311	41	32.1	36,981,786	718	4	1.2	1,422,128	92
24	1,214,401	76	43.3	52,555,631	1533	18	7.8	9,423,016	665
25	855,371	28	54.9	46,926,968	641	3	1.5	1,242,702	81
29	745,790	27	52.9	39,445,406	727	8	4.2	3,143,986	210
30	1,222,773	52	43.9	53,696,736	1238	13	5.6	6,887,077	465
31	333,728	7	41.9	13,990,464	383	15	6.4	2,145,841	133
32	1,469,825	25	52.2	76,729,064	1833	12	6.1	8,912,781	580
Deer Is.	**10,688,771**	**515**	**34.7**	**371,071,557**	**8,681**	**12**	**4.0**	**43,281,056**	**2,965**
35	1,300,620	69	123.3	160,320,934	2614	8	9.3	12,083,410	817
36	789,148	52	25.4	20,078,353	570	19	4.8	3,765,617	261
37	1,208,335	40	4.6	5,596,353	233	33	1.5	1,836,237	141
38	3,143,019	62	20.7	65,185,576	1877	16	3.3	10,287,820	728
43	482,051	24	20.8	10,010,358	355	21	4.3	2,058,520	146
45	621,045	60	17.8	11,057,660	389	28	4.9	3,073,272	241
46	856,109	20	19.7	16,860,015	394	14	2.7	2,336,172	169
48	1,134,030	41	31.5	35,727,546	1041	16	5.2	5,893,155	421
53	3,881,472	105	14.8	57,568,516	1500	18	2.7	10,322,540	758
54	3,396,153	30	2.0	6,792,306	167	9	0.2	625,607	39
Letete	**16,811,982**	**503**	**23.2**	**389,197,617**	**9,141**	**13**	**3.1**	**52,282,351**	**3,721**
Grand Total	**36,872,749**	**1,443**	**24.4**	**901,359,033**	**20,923**	**12**	**3.0**	**110,242,578**	**7,700**

Table 8. Summary of biomass calculations for Campobello, Deer Island and Letete to Pocologan areas, during the 2002-03 surveys (depth of 0 to 10 m).

Locations	Area m²	No of Sections	Total number of urchins			Legal size urchins ≥ 51 mm TD			
			Mean #/m²	Number of Urchins	Biomass (t)	Percent (%)	Mean #/m²	Number of Urchins	Biomass (t)
1	453.568	21	71.4	32,365,317	872	8	6.0	2,733,071	163
2	1,503,081	39	40.9	61,528,043	1737	10	4.0	5,954,327	366
3	1,096,689	15	0.3	365,563	10	26	0.1	96,006	7
4	285,868	23	23.0	6,569,992	187	13	3.1	882,226	55
5	213,676	9	49.1	10,481,995	450	29	14.5	3,089,065	201
7	443,237	15	25.1	11,113,429	437	25	6.3	2,778,357	175
14	1,149,266	21	2.7	3,078,391	114	13	0.3	386,658	25
15	137,725	22	83.0	11,426,167	210	6	4.8	663,027	40
16	132,589	27	31.3	4,145,125	107	13	4.0	526,517	33
Campobello	**5,415,699**	**192**	**26.0**	**141,074,021**	**4124**	**12**	**3.2**	**17,109,255**	**1,063**
18	909,150	36	32.0	29,092,800	559	9	2.8	2,502,606	153
19	1,815,680	121	7.8	14,162,304	457	13	1.0	1,832,071	118
20	635,923	6	56.7	36,056,834	899	6	3.2	2,043,440	138
24	807,432	41	43.1	34,800,319	897	9	3.9	3,109,154	192
25	528,021	6	59.3	31,311,645	722	6	3.3	1,744,381	107
29	421,310	28	21.7	9,142,427	269	13	2.9	1,212,437	74
30	754,969	27	30.3	22,875,561	520	6	1.9	1,423,515	89
31	158,681	1	45.5	7,219,986	197	3	1.3	208,269	13
32	668,448	9	46.6	31,149,677	749	7	3.2	2,130,520	136
Deer Is.	**6,699,614**	**275**	**32.2**	**215,811,553**	**5,268**	**8**	**2.4**	**16,206,394**	**1,020**
35	916,123	35	75.0	68,709,230	1387	4	3.1	2,860,962	168
36	296,009	27	29.5	8,732,264	243	10	3.0	887,282	55
37	913,346	34	0.7	639,342	26	17	0.1	109,476	6
38	1,480,111	37	22.1	32,710,444	909	14	3.0	4,435,314	285
43	431,145	6	60.4	26,041,166	720	7	4.4	1,902,551	116
45	469,486	10	56.5	26,525,971	716	8	4.3	2,040,459	126
46	439,760	18	50.0	21,987,988	532	9	4.6	2,034,322	128
48	567,150	28	53.6	30,399,256	656	8	4.2	2,409,549	153
53	2,247,236	92	26.4	59,327,039	1590	18	4.8	10,882,976	754
54	3,396,153	30	10.4	35,319,991	1201	25	2.6	8,932,672	620
Letete	**11,156,519**	**317**	**27.8**	**310,392,690**	**7,980**	**12**	**3.3**	**36,495,564**	**2,412**
Grand Total	**23,271,832**	**784**	**28.7**	**667,278,264**	**17,371**	**10**	**3.0**	**69,811,213**	**4,496**

Table 9. Summary of biomass calculations for Campobello, Deer Island, and Letete to Pocologan areas, during the 2002-03 surveys (depth of 11 to 20 m).

Locations	Area m²	No of Sections	Total number of urchins			Legal size urchins ≥ 51 mm TD			
			Mean #/m²	Number of Urchins	Biomass (t)	Percent (%)	Mean #/m²	Number of Urchins	Biomass (t)
1	441,558	29	45.2	19,968,319	243	1.3	0.6	254,779	15
2	1,068,704	25	7.2	7,686,119	202	17.2	1.2	1,323,438	87
3	974,218								
4	450,013								
5	453,706	6	14.9	6,748,877	214	13.9	2.1	935,488	59
7	144,283								
14	191,769	6	4.7	902,912	29	13.7	0.6	123,929	8
15	74,038	6	31.6	2,337,133	8	0.0	0.0	0	0
16	158,008	9	17.9	2,820,443	45	4.5	0.8	126,154	8
Campobello	**3,956,297**	**81**	**10.2**	**40,463,803**	**742**	**6.8**	**0.7**	**2,763,788**	**177**
18	331,103	17	0.0	0	0	0.0		0	0
19	638,639	54	0.9	555,616	15	11.6	0.1	64,695	4
20	516,388	10	4.3	2,194,649	52	6.8	0.3	148,430	9
24	406,969	17	16.2	6,591,677	118	8.6	1.4	566,852	38
25	327,350	4	5.4	1,751,323	0	0.0		0	0
29	324,480	12	10.4	3,366,480	63	6.5	0.7	219,172	15
30	467,804	26	15.7	7,339,845	67	1.0	0.2	70,575	4
31	175,047	3	20.0	3,503,741	136	19.6	3.9	688,235	40
32	801,377	8	31.2	24,987,736	444	4.3	1.3	1,063,308	68
Deer Is.	**3,989,157**	**151**	**12.6**	**50,291,066**	**894**	**5.6**	**0.7**	**2,821,267**	**179**
35	384,497	17	97.0	37,296,203	308	0.7	0.7	258,403	16
36	493,139	15	3.2	1,578,045	14	0.0	0.0	0	0
37	294,989	4	0.4	117,996	6	44.6	0.2	52,600	4
38	1,662,908	20	1.2	1,995,490	85	35.5	0.4	708,781	65
43	50,906	2	4.1	208,714	5	5.9	0.2	12,277	1
45	151,559	15	13.3	2,015,732	65	23.0	3.1	463,667	34
46	416,349	3	0.4	166,540	0	0.0	0.0	0	0
48	566,880	8	8.6	4,875,166	148	26.5	2.3	1,293,411	100
53	1,634,236	9	0.0	0	0	0.0	0.0	0	0
54	0						0.0		
Letete	**5,655,463**	**93**	**8.5**	**48,253,885**	**632**	**5.8**	**0.5**	**2,789,140**	**218**
Grand Total	**13,600,917**	**325**	**10.2**	**139,008,754**	**2,269**	**6.0**	**0.6**	**8,374,195**	**575**

Table 10. Summary of biomass calculations for Campobello, Deer Island, and Letete to Pocologan areas, during the 2002-03 surveys (all depth combined).

Locations	Area m²	No of Sections	Total number of urchins			Legal size urchins ≥ 51 mm TD			
			Mean #/m²	Number of Urchins	Biomass (t)	Percent (%)	Mean #/m²	Number of Urchins	Biomass (t)
1	895,126	50	58	52,333,635	1115	6	3.3	2,987,850	177
2	2,571,785	64	27	69,214,162	1940	11	2.8	7,277,764	452
3	2,070,907	15	0	365,563	10	26	0.0	96,006	7
4	735,881	23	9	6,569,992	187	13	1.2	882,226	55
5	667,382	15	26	17,230,872	664	23	6.0	4,024,553	260
7	587,520	15	19	11,113,429	437	25	4.7	2,778,357	175
14	1,341,035	27	3	3,981,303	144	13	0.4	510,587	33
15	211,763	28	65	13,763,300	218	5	3.1	663,027	40
16	290,597	36	24	6,965,568	152	9	2.2	652,671	41
Campobello	**9,371,996**	**273**	**19**	**181,537,824**	**4866**	**11**	**2.1**	**19,873,043**	**1,240**
18	1,240,253	53	23	29,092,800	559	9	2.0	2,502,606	153
19	2,454,319	175	6	14,717,920	472	13	0.8	1,896,766	122
20	1,152,311	16	33	38,251,483	951	6	1.9	2,191,871	148
24	1,214,401	58	34	41,391,996	1015	9	3.0	3,676,006	230
25	855,371	10	39	33,062,968	722	5	2.0	1,744,381	107
29	745,790	40	17	12,508,907	332	11	1.9	1,431,608	88
30	1,222,773	53	25	30,215,405	587	5	1.2	1,494,091	93
31	333,728	4	32	10,723,726	332	8	2.7	896,504	53
32	1,469,825	17	38	56,137,413	1193	6	2.2	3,193,828	205
Deer Is.	**10,688,771**	**426**	**25**	**266,102,619**	**6,162**	**7**	**1.8**	**19,027,662**	**1,200**
35	1,300,620	52	82	106,005,433	1695	3	2.4	3,119,365	184
36	789,148	42	13	10,310,309	257	9	1.1	887,282	55
37	1,208,335	38	1	757,338	32	21	0.1	162,077	10
38	3,143,019	57	11	34,705,934	994	15	1.6	5,144,095	350
43	482,051	8	54	26,249,880	725	7	4.0	1,914,828	117
45	621,045	25	46	28,541,703	782	9	4.0	2,504,126	160
46	856,109	21	26	22,154,528	532	9	2.4	2,034,322	128
48	1,134,030	36	31	35,274,421	804	10	3.3	3,702,960	253
53	3,881,472	101	15	59,327,039	1590	18	2.8	10,882,976	754
54	3,396,153	30	10	35,319,991	1201	25	2.6	8,932,672	620
Letete	**16,811,982**	**410**	**21**	**358,646,575**	**8,612**	**11**	**2.3**	**39,284,704**	**2,631**
Grand Total	**36,872,749**	**1,109**	**22**	**806,287,018**	**19,640**	**10**	**2.1**	**78,185,408**	**5,071**

Table 11. Summary of biomass calculations for the Maces Bay area (Maces Bay to Chance Harbour), during the 2002 survey.

Locations	Area m²	No of Sections	Total number of urchins			Legal size urchins ≥ 51 mm TD			
			Mean #/m²	Number of Urchins	Biomass (t)	Percent (%)	Mean #/m²	Number of Urchins	Biomass (t)
55	1,001,673	30	3.7	3,741,249	141	22	0.8	823,831	55
56	755,659	15	0.0	0	0		0.0	0	0
57	1,247,928	43	13.0	16,223,064	562	24	3.1	3,864,551	246
58	1,368,184	15	0.2	273,637	7	27	0.1	72,739	5
59	1,872,832	109	34.7	65,077,166	2106	22	7.7	14,352,683	990
60	1,399,227	90	27.2	38,058,974	786	9	2.5	3,451,311	225
61	2,066,984	145	11.2	23,098,546	854	28	3.1	6,437,776	458
62	1,166,801	69	6.3	7,350,846	409	49	3.1	3,599,334	297
63	545,135	25	6.7	3,640,412	168	35	2.3	1,262,500	92
64	871,311	48	2.6	2,265,409	136	53	1.4	1,192,863	103
65	1,041,000	30	1.4	1,457,400	64	36	0.5	519,160	39
0 to 10 m	**13,336,734**	**619**	**12.1**	**161,186,703**	**5232**	**22**	**2.7**	**35,576,747**	**2,510**
55	123,124								
56									
57									
58	38,519								
59	778,465	21	2.1	1,616,093	36	19	0.4	307,058	23
60									
61	347,101	19	12.0	4,179,790	119	19	2.2	778,422	58
62	861,660	33	2.7	2,326,482	128	48	1.3	1,110,895	95
63	445,972	20	0.1	53,517	3	44	0.1	23,314	2
64	275,556	18	1.5	426,285	24	47	0.7	201,431	17
65	237,721								
11 to 20 m	**3,108,118**	**111**	**2.8**	**8,602,167**	**311**	**28**	**0.8**	**2,421,121**	**196**
55	1,124,797	30	3.3	3,741,249	141	22	0.7	823,831	55
56	755,659	15	0.0	0	0	0	0.0	0	0
57	1,247,928	43	13.0	16,223,064	562	24	3.1	3,864,551	246
58	1,406,703	15	0.2	273,637	7	27	0.1	72,739	5
59	2,651,297	130	25.2	66,693,260	2,143	22	5.5	14,659,741	1,013
60	1,399,227	90	27.2	38,058,974	786	9	2.5	3,451,311	225
61	2,414,085	164	11.3	27,278,336	973	26	3.0	7,216,198	516
62	2,028,461	102	4.8	9,677,328	537	49	2.3	4,710,229	392
63	991,107	45	3.7	3,693,928	170	35	1.3	1,285,814	94
64	1,146,867	66	2.3	2,691,694	160	52	1.2	1,394,295	120
65	1,278,721	30	1.1	1,457,400	64	36	0.4	519,160	39
Combined	**16,444,852**	**730**	**10.3**	**169,788,870**	**5,543**	**22**	**2.3**	**37,997,868**	**2,706**

Table 12. Biomass estimates (t) based on the 1992-94 survey result which includes all locations from 1 to 54.

1992-94	0 to 10 m		11 to 20 m		Combined	
Area	Total	Fishable	Total	Fishable	Total	Fishable
Campobello	4110	1736	1070	197	5180	1933
Deer Is.	12660	4265	4574	991	17234	5256
Letete to Pocologan	10189	5237	1897	819	12086	6056
Total	26959	11238	7541	2007	34500	13245

Table 13. Biomass estimates (t) based on the 1992-94 and 2002-2003 survey result, which includes only the locations that were resurveyed in 2002-03 and the Maces Bay locations.

1992-94	0 to 10 m		11 to 20 m		Combined	
Area	Total	Fishable	Total	Fishable	Total	Fishable
Campobello	2279	938	821	76	3100	1014
Deer Is.	7269	2538	1412	427	8681	2965
Letete to Pocologan	7438	3128	1703	593	9141	3721
Total	16986	6604	3936	1097	20922	7700

2002-03	0 to 10 m		11 to 20 m		Combined	
Area	Total	Fishable	Total	Fishable	Total	Fishable
Campobello	4124	1063	742	177	4866	1240
Deer Is.	5268	1020	894	179	6162	1200
Letete to Pocologan	7980	2412	632	218	8612	2631
Total	17372	4496	2268	575	19640	5071

2002-03	0 to 10 m		11 to 20 m		Combined	
Area	Total	Fishable	Total	Fishable	Total	Fishable
Maces Bay	5232	2510	311	196	5543	2706

10. FIGURES
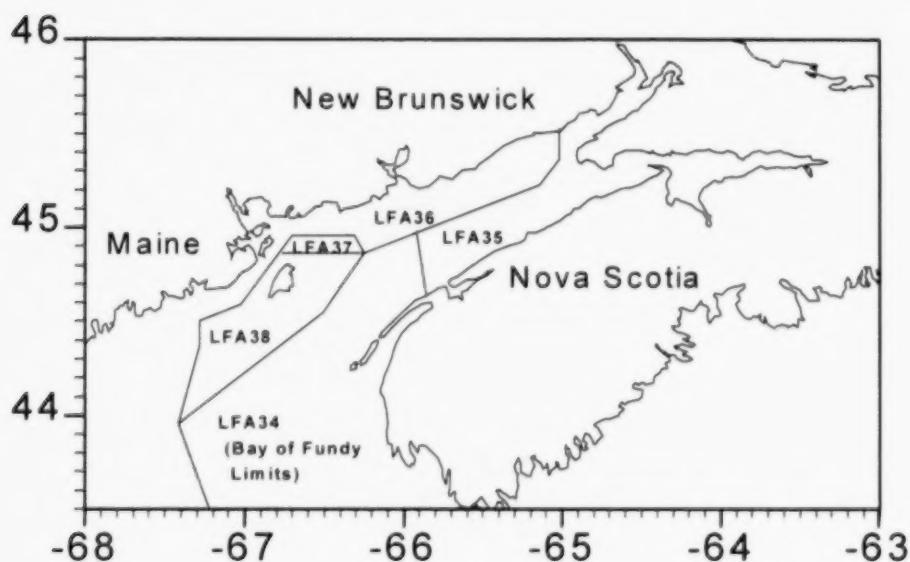
Figure 1. Bay of Fundy/Gulf of Maine map showing Lobster Fishing Areas (LFAs) 35, 36, 37, and, 38, and adjacent LFA 34.
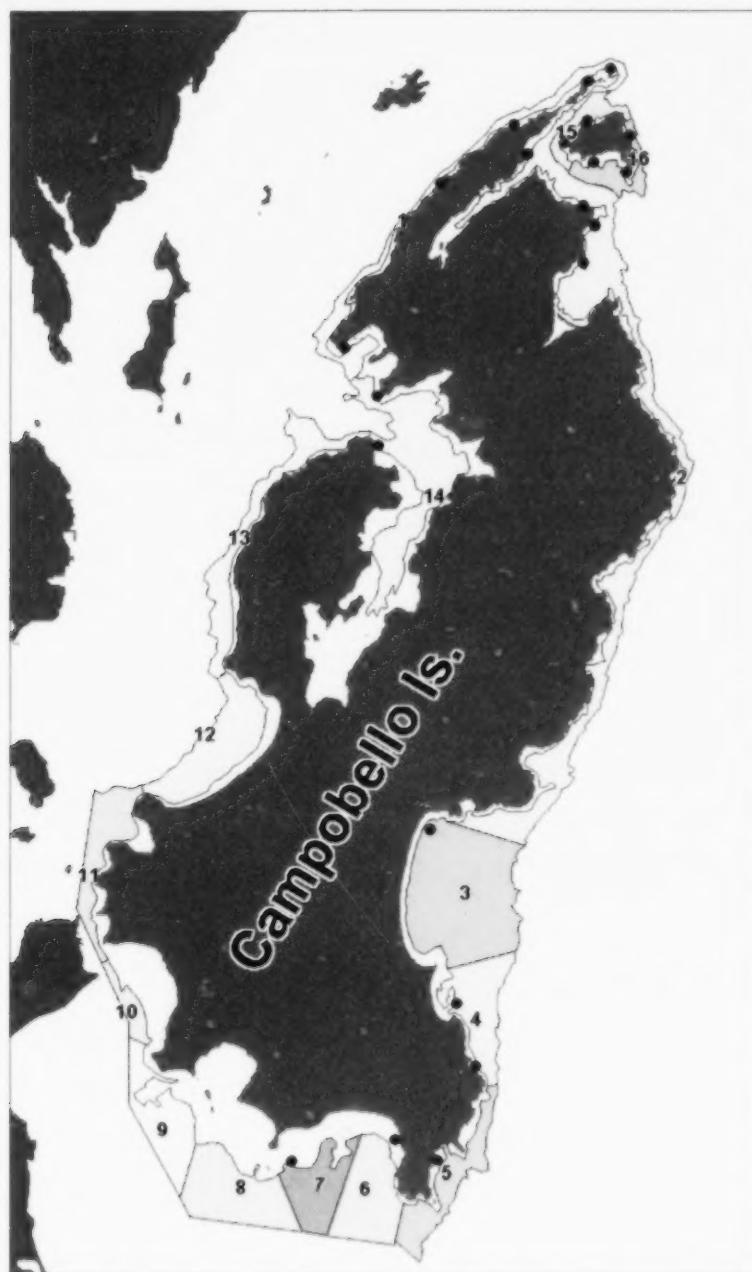
Figure 2. Map showing the locations (shaded area) and the position of each transect sampled (●) around Campobello Island during 2002.

Figure 3. Map showing the locations (shaded area) and the positions of each transect sampled (●) around Deer Island during 2002-03.
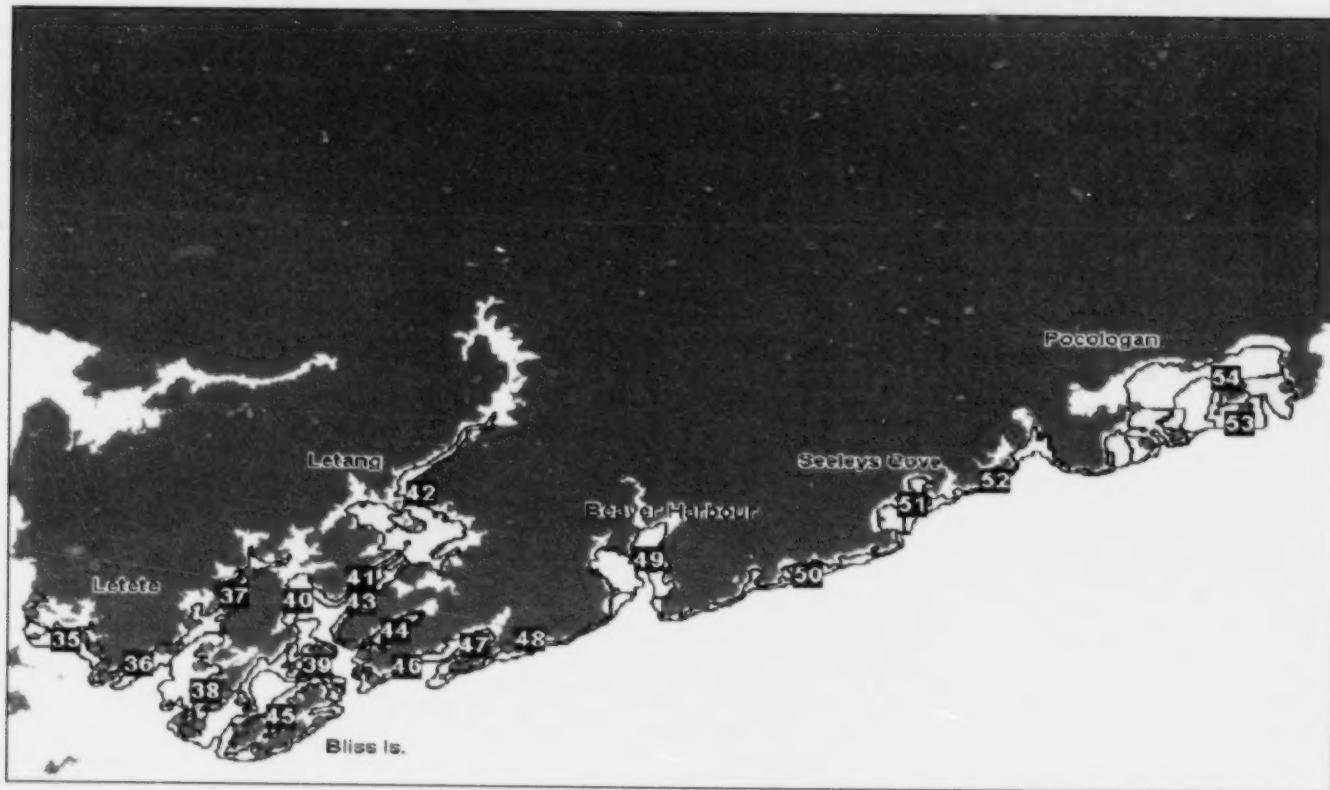
Figure 4. Map showing the locations (shaded area) and the positions of each transect sampled (●) in the Letete to Pocologan area during 2003.
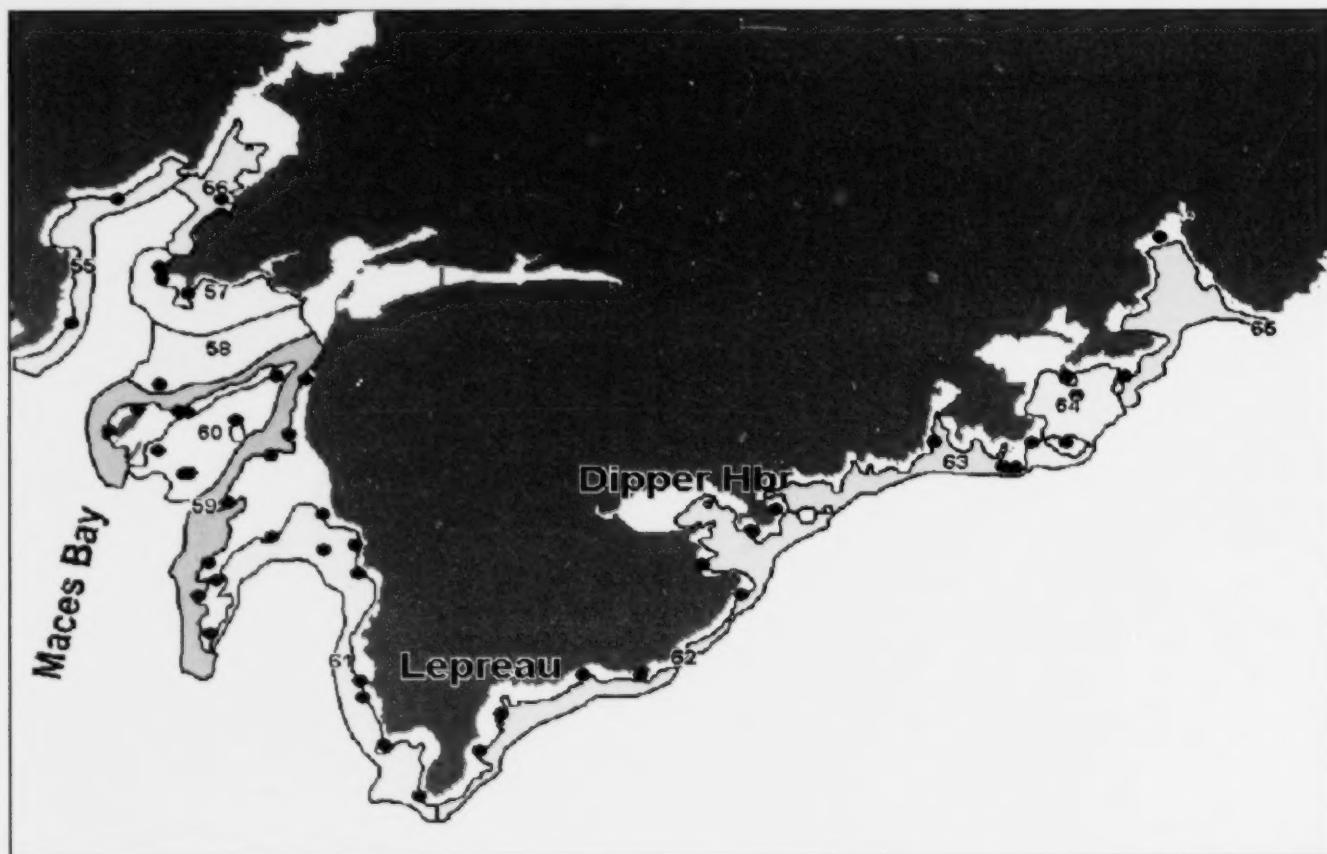
Figure 5. Map showing the locations (shaded area) and the position of each transect sampled (●) in the Maces Bay area (from Maces Bay to Chance Harbour) during 2002.
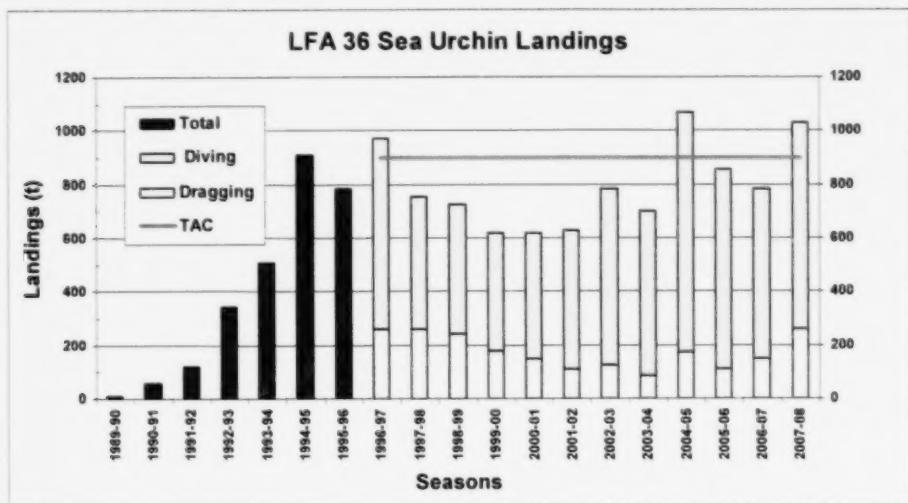
Figure 6. Lobster Fishing Area (LFA) 36 historical landings and total allowable catch (TAC) in metric tons (t).
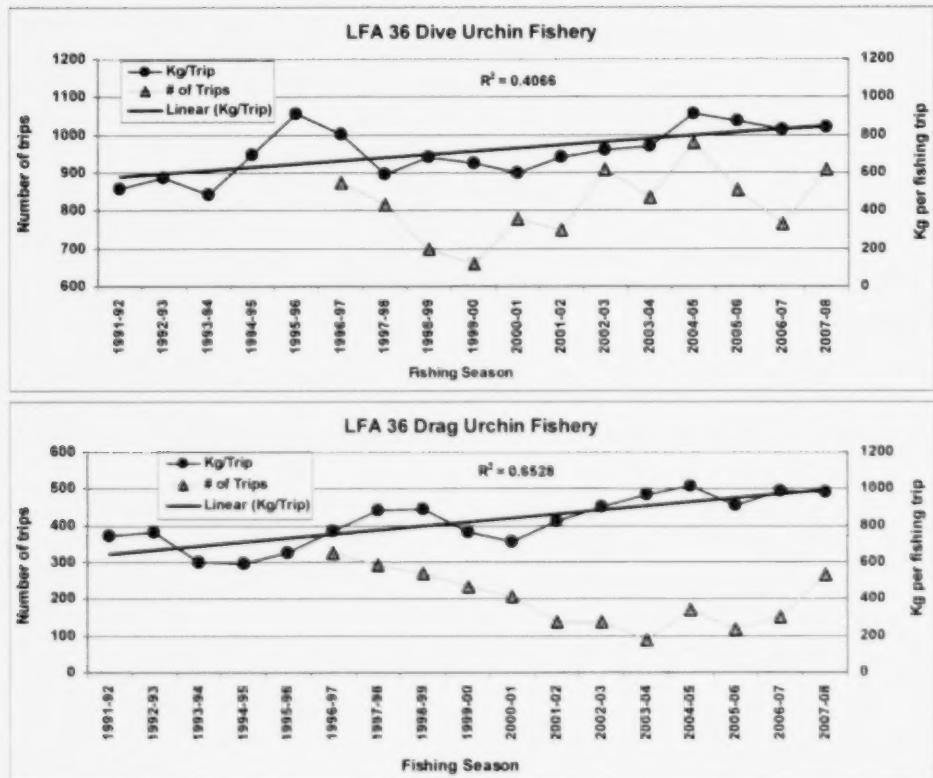
Figure 7. The average catch in kilograms per fishing trip and the number of trips per season for the LFA 36 diving fishery (top) and drag fishery (bottom) from the 1991-92 to 2007-08 fishing seasons.
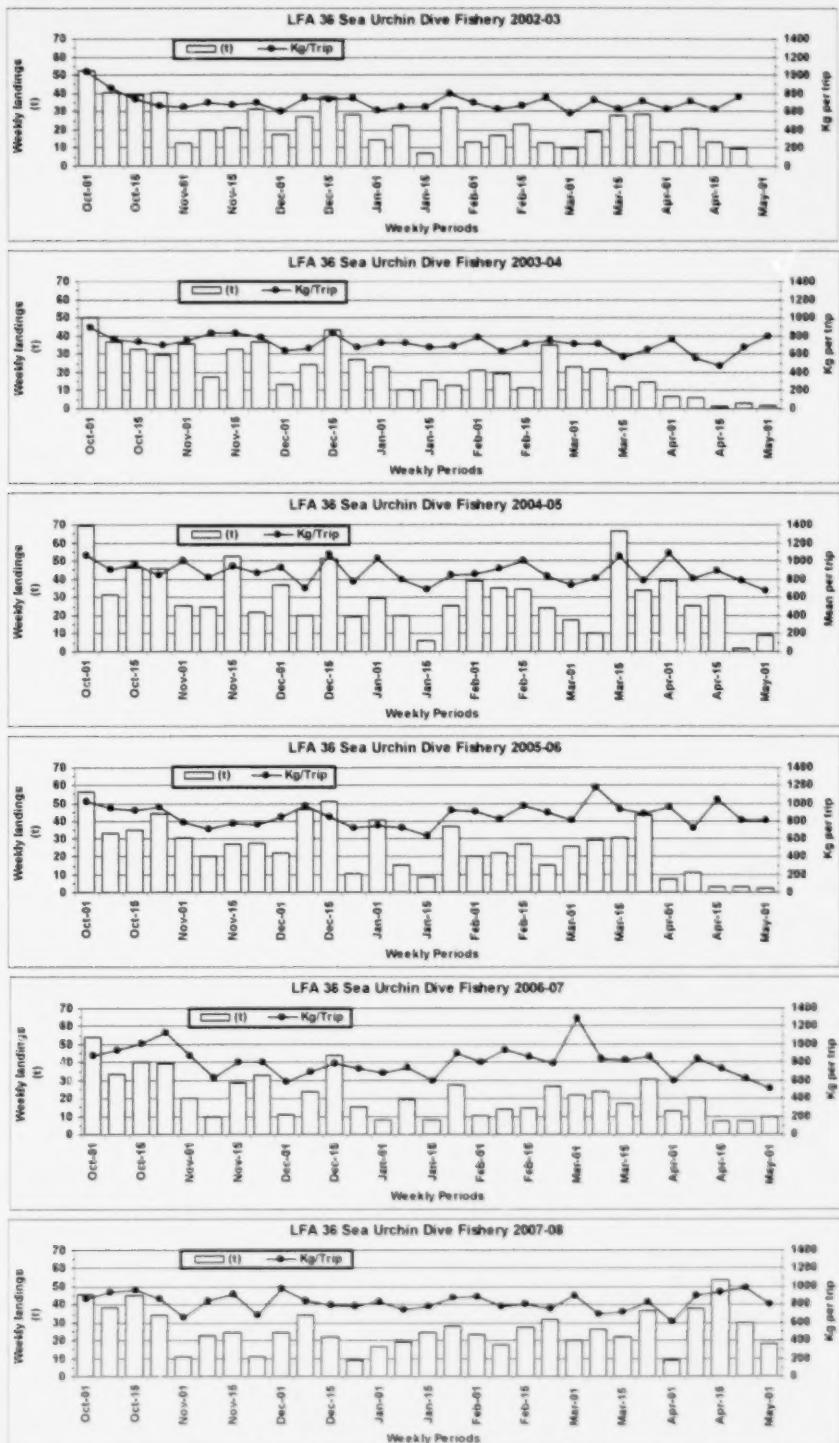
Figure 8. Weekly landings and catch rate (kg/trip) for the urchin dive fishery in Lobster Fishing Area (LFA) 36 during each fishing season between 1996-97 and 2007-08.
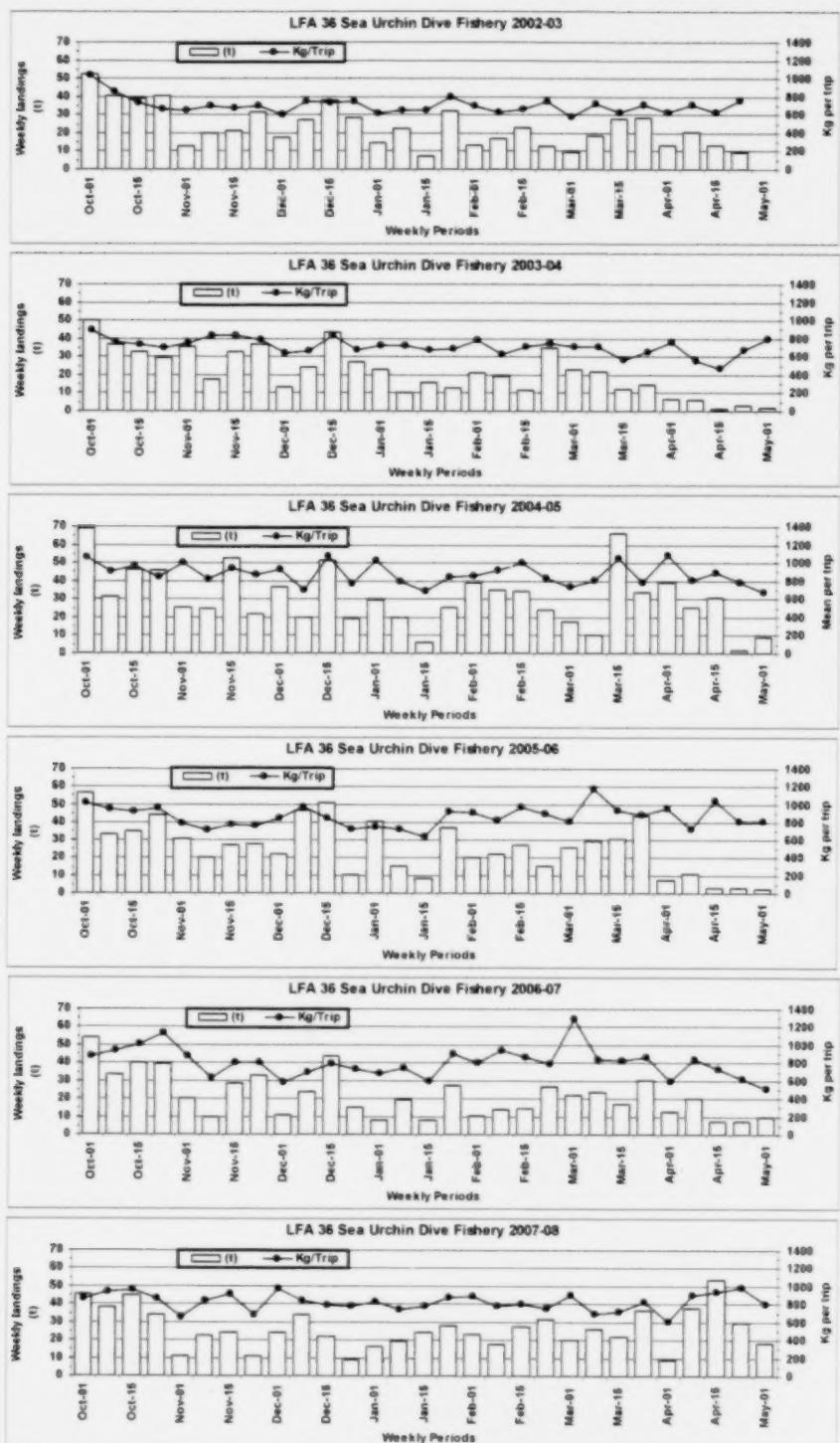
Figure 8. Continued.
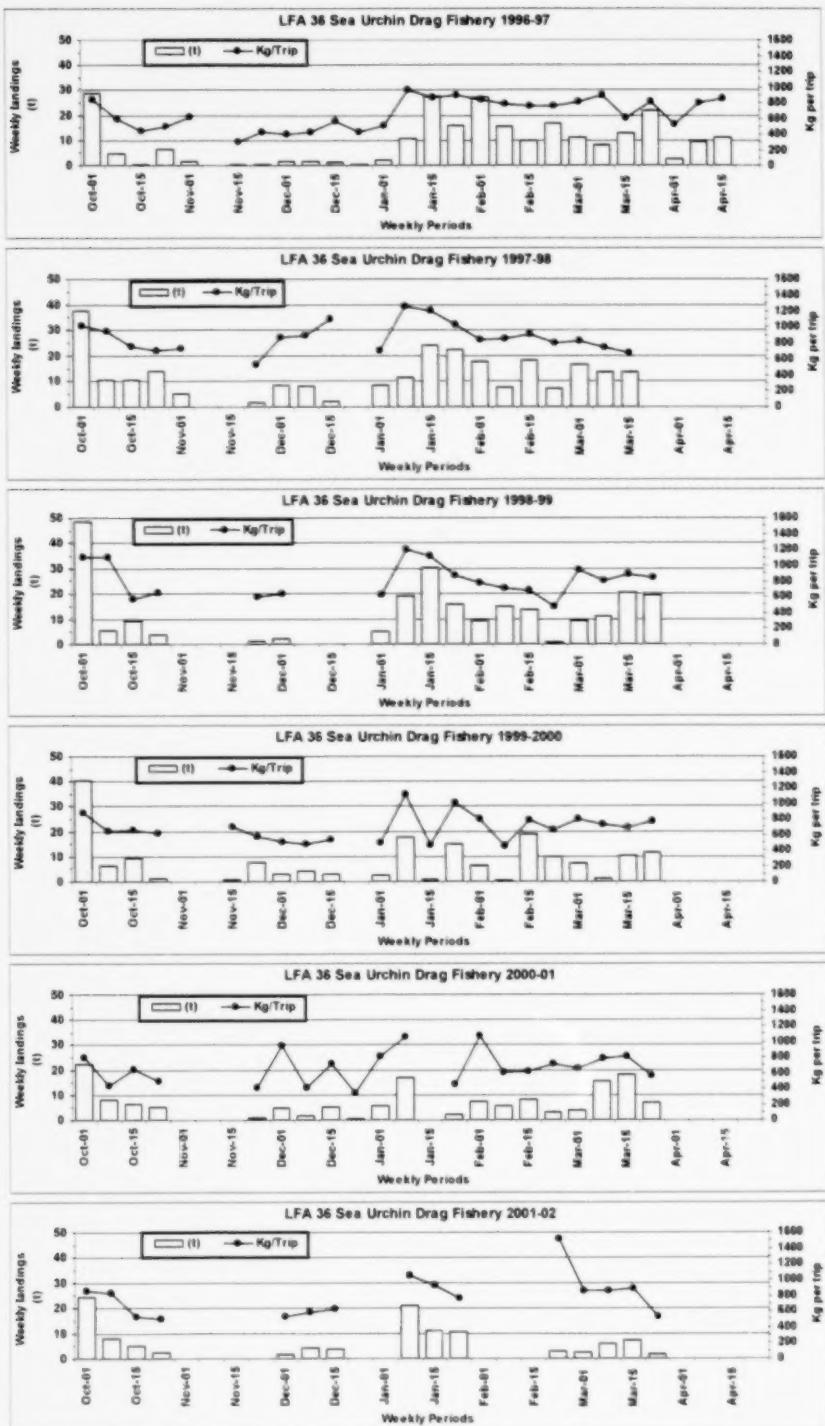
Figure 9. Weekly landings and catch rate (kg/trip) for the urchin drag fishery in Lobster Fishing Area (LFA) 36 during each fishing season between 1996-97 and 2007-08.
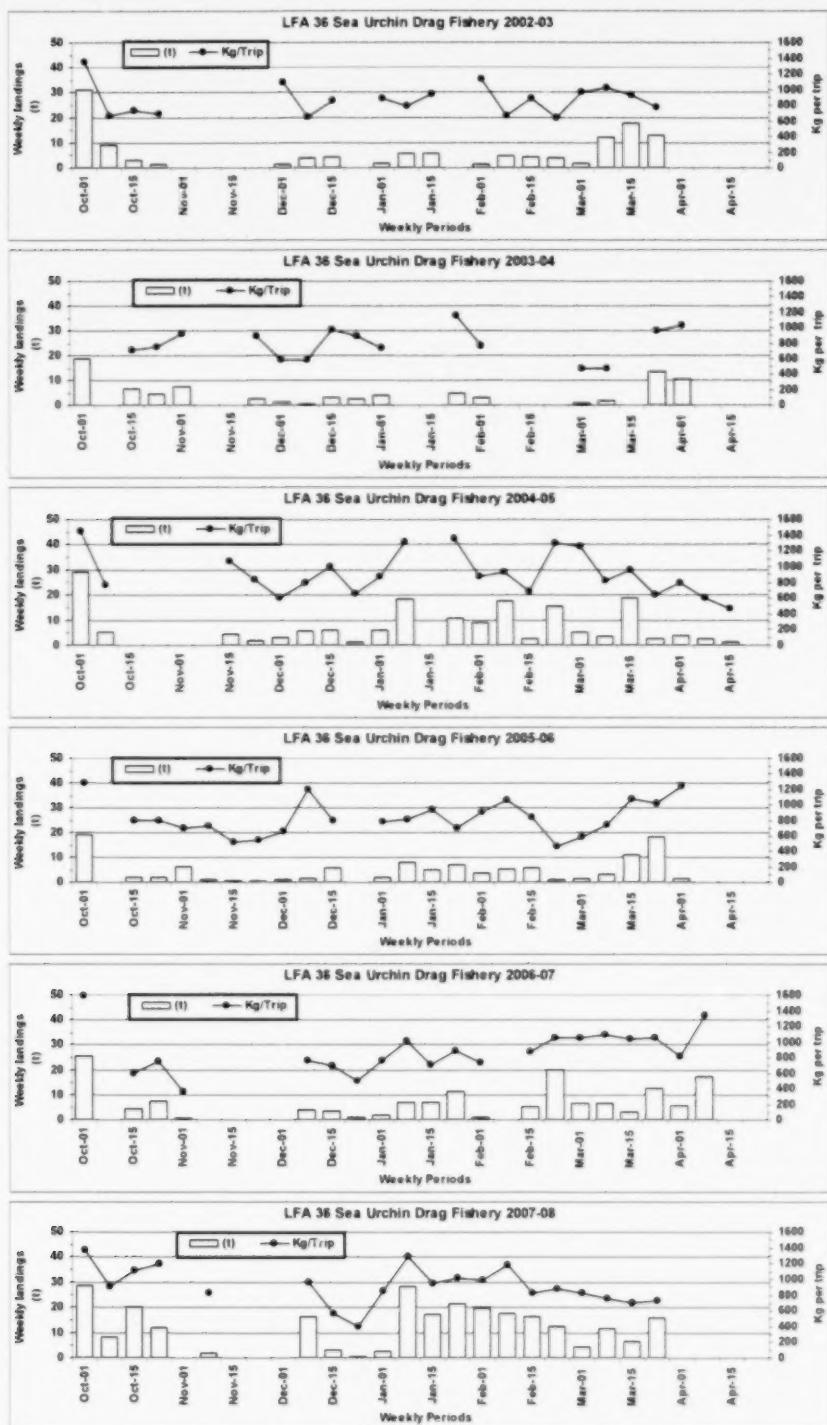
Figure 9. Continued.
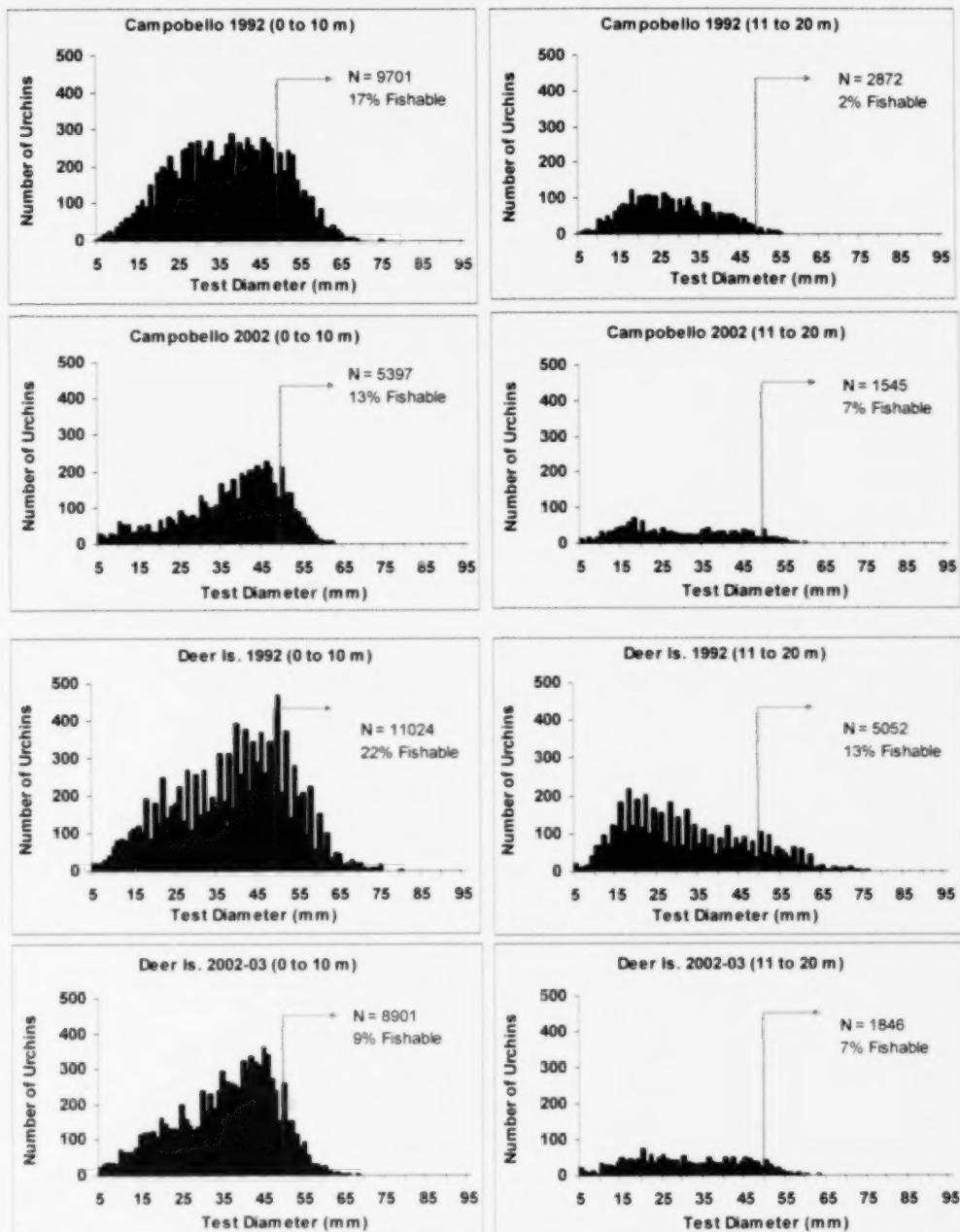
Figure 10. Size frequency distribution of the total number of sea urchins sampled off Campobello (top) and Deer Island (bottom) in 1992 and 2002 for the 0 to 10 m depth stratum (left) and the 11 to 20 m depth stratum (right).
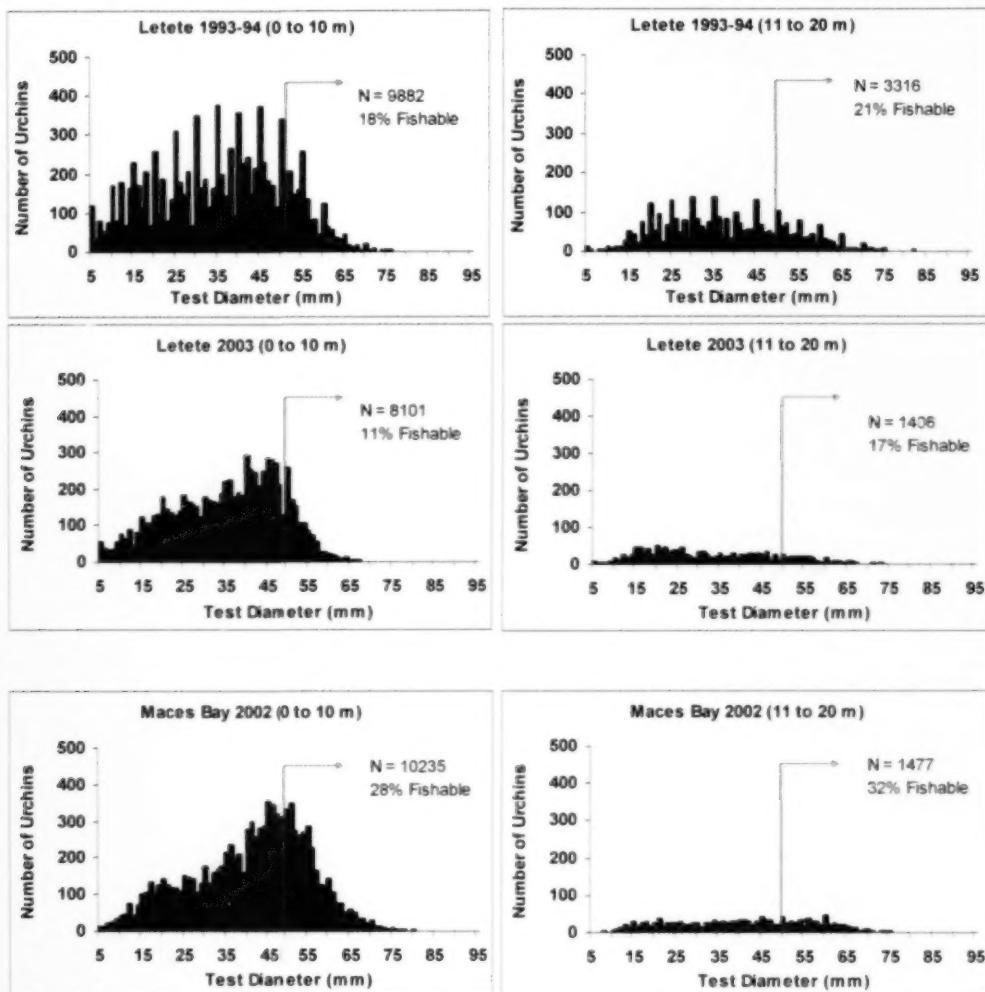
Figure 11. Size frequency distribution of the total number of sea urchins sampled Letete to Pocologan (top) and Maces Bay to Chance Harbour (bottom) in 1992-94 and 2002-03 for the 0 to 10 m depth stratum (left) and the 11 to 20 n depth stratum (right).
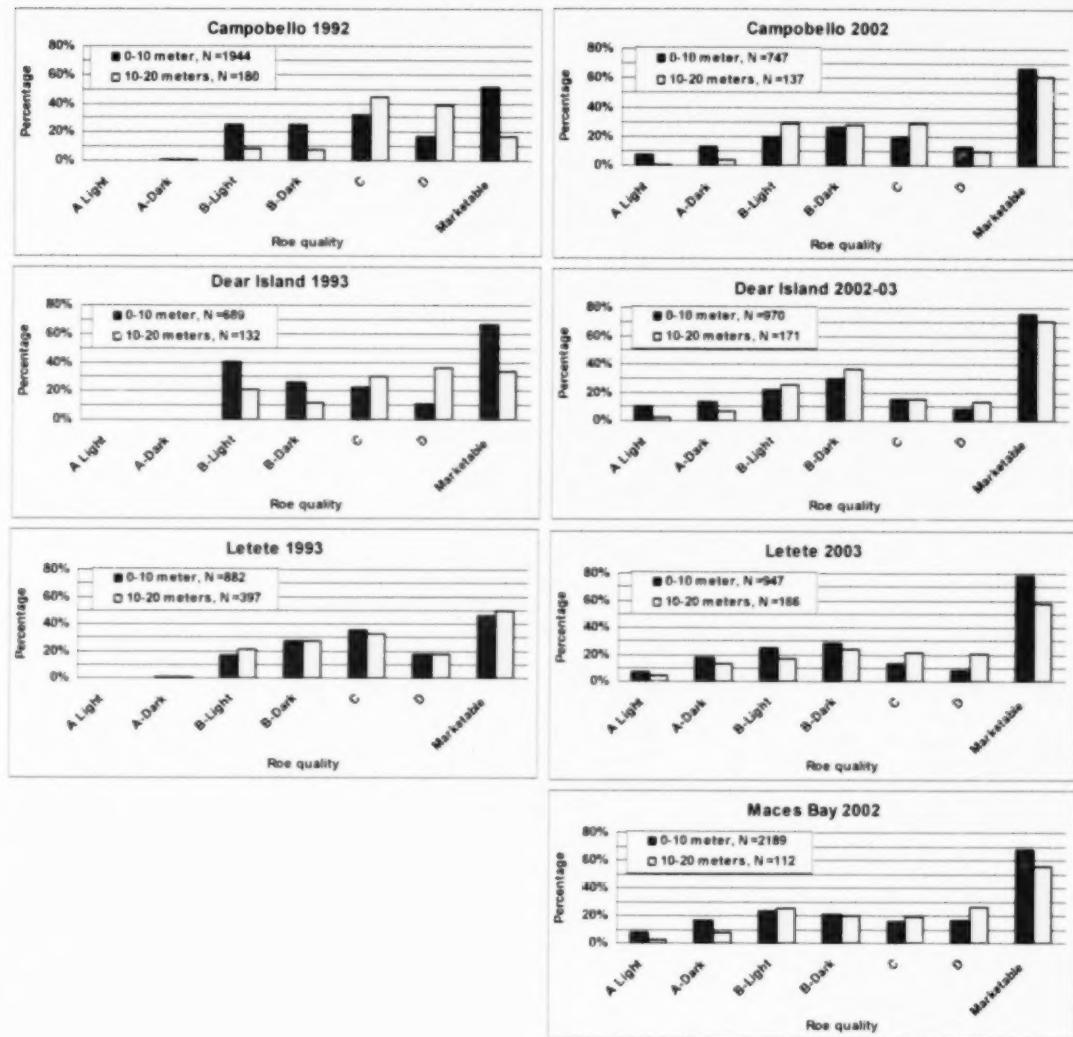
Figure 12. Roe quality by Grade categories as a percentage of the total number (N) of legal size urchins tested during each survey periods (1993-94 and 2002-03) for each survey area and depth stratum. Only roe quality that falls within Grade A and B is considered marketable. Grade A being the best quality roe and Grade C and D the worst or non commercial roe.
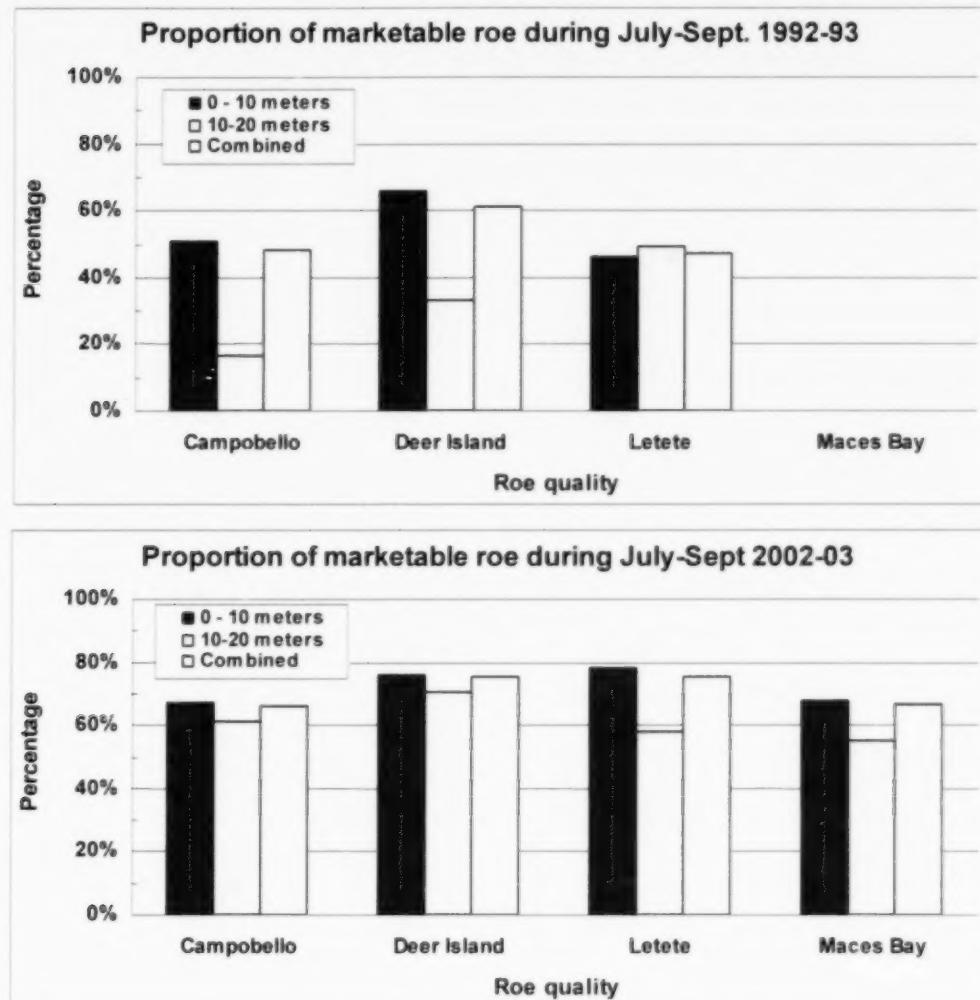
Figure 13. Proportion of marketable roe for each survey periods (1993-94 and 2002-03) and for each depth stratum and all depth combined within each survey period.
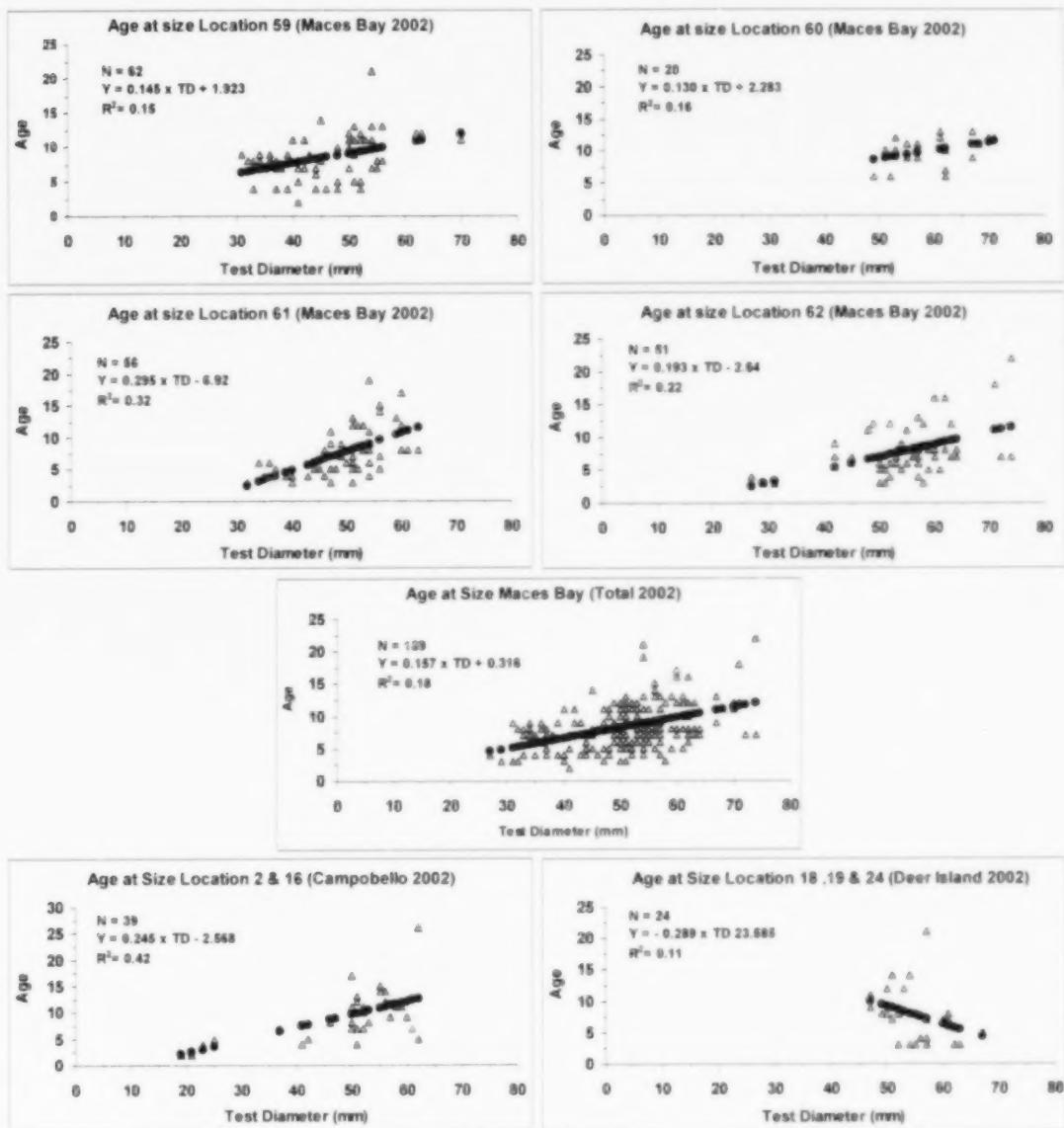
Figure 14. Test diameter versus age for the Maces Bay area (locations 59, 60, 61, and 62) and Campobello (locations 2 and 16) during 2002.

11. APPENDICES

Appendix 1. Map showing the location of fishing areas as recorded by fishers in the new area based urchin logbook which was introduced during fall 2008.
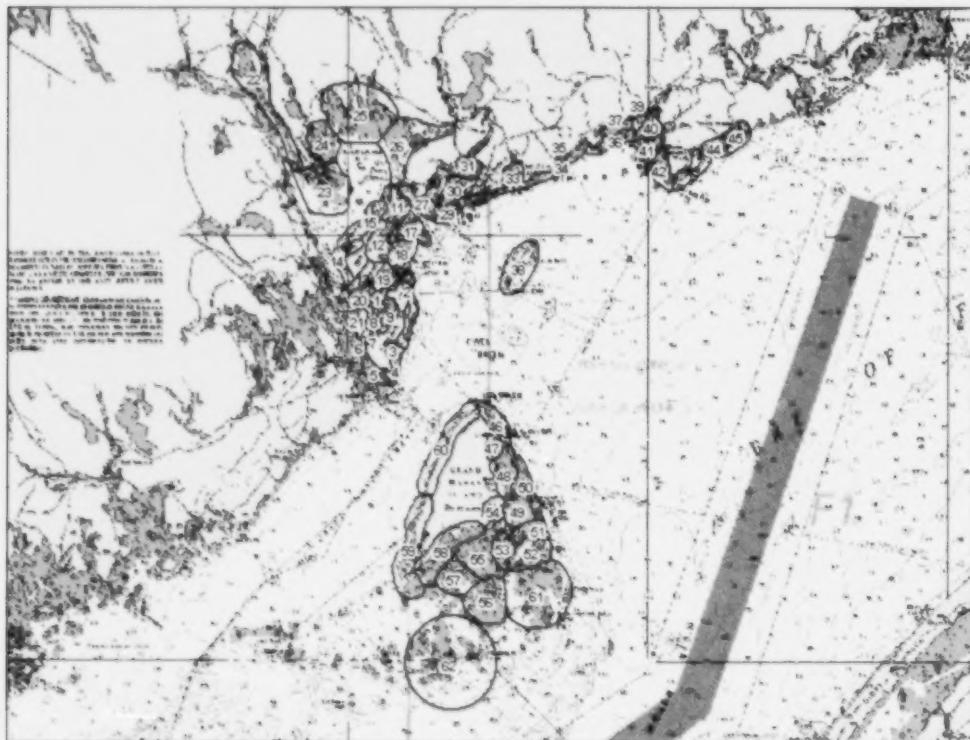
Appendix 2. Calculation of mean, minimum, and maximum number of sea urchins for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Campobello Island fishing area based on the 1992 survey data.

A Locations (0 to 10 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
1	65	40	31	3.9	8	32	47	453,568	17,940,359	14,417,124	21,463,594
2	98	26	23	2.3	5	21	30	1,503,081	38,491,911	31,523,352	45,460,469
3	15	0	0	0.0	0	0	0	1,096,689	0	0	0
4	14	22	24	6.5	14	8	36	285,868	6,348,312	2,361,249	10,335,374
5	28	17	14	2.6	5	12	23	213,676	3,737,041	2,592,517	4,881,565
7	15	8	7	1.7	4	5	12	443,237	3,748,308	2,136,163	5,360,452
14	21	1	3	0.7	1	0	3	1,149,266	1,327,129	0	3,009,225
15	18	25	22	5.2	11	13	36	137,725	3,375,028	1,853,295	4,896,760
16	26	34	39	7.7	16	18	50	132,589	4,475,134	2,361,157	6,589,111
Total	**300**	**15**			**4**	**11**	**19**	**5,415,699**	**79,443,219**	**57,244,857**	**101,996,549**

B Locations (11 to 20 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min #/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
1	53	20	12	1.7	3	17	24	441,558	8,916,972	7,418,776	10,415,169
2	34	17	10	1.8	4	14	21	1,068,704	18,648,885	14,751,274	22,546,495
3								974,218			
4	1	40	0	0.0	0	40	40	450,013	18,090,523	18,090,523	18,090,523
5	17	27	8	2.0	4	23	31	453,706	12,314,115	10,404,661	14,223,568
7								144,283			
14	6	0	0	0.0	0	0	0	191,769	0	0	0
15	4	13	3	1.6	5	8	18	74,038	961,569	591,873	1,331,264
16	10	17	16	5.0	11	6	29	158,008	2,714,577	923,446	4,505,709
Total	**125**	**16**			**2**	**13**	**18**	**3,956,297**	**61,646,640**	**52,180,552**	**71,112,729**

C Locations (combined)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
1	118	30			6	24	36	895126	26857331	21835899	31878763
2	132	22			4	18	26	2571785	57140795	46274627	68006964
3	15	0			0	0	0	2070907	0	0	0
4	15	33			5	28	39	735881	24438834	20451772	28425896
5	45	24			5	19	29	667382	16051155	12997178	19105133
7	15	6			3	4	9	587520	3748308	2136163	5360452
14	27	1			1	0	2	1341035	1327129	0	3009225
15	22	20			9	12	29	211763	4336596	2445168	6228024
16	36	25			13	11	38	290597	7189711	3284602	11094820
Total	**425**	**15**			**3**	**12**	**18**	**9,371,996**	**141,089,859**	**109,425,409**	**173,109,278**

Appendix 3. Calculation of mean, minimum, and maximum number of sea urchins for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Campobello Island fishing area based on the 2002 survey data.

A Locations (0 to 10 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	95 % CL Min.#/m²	95 % CL Max.#/m²	Area m²	Total No. of urchins	95 % CL Min. No.	95 % CL Max. No.
1	21	71	40	8.7	18	53	89	453,568	32,365,317	24,144,558	40,586,075
2	39	41	33	5.3	11	30	52	1,503,081	61,528,043	45,421,504	77,634,581
3	15	0.3	1	0.3	1	0	1	1,096,689	365,563	0	1,149,618
4	23	23	20	4.2	9	14	32	285,868	6,569,992	4,092,186	9,047,799
5	9	49	19	6.3	14	35	64	213,676	10,481,995	7,387,242	13,576,748
7	15	25	17	4.4	9	16	35	443,237	11,113,429	6,911,458	15,315,401
14	21	3	8	1.7	3	-1	6	1,149,266	3,078,391	0	7,041,630
15	22	83	49	10.4	22	61	105	137,725	11,426,167	8,451,213	14,401,120
16	27	31	32	6.2	13	18	44	132,589	4,145,125	2,443,671	5,846,579
Total	**192**	**26**			**8**	**18**	**34**	**5,415,699**	**141,074,021**	**98,851,831**	**184,599,552**

B Locations (11 to 20 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	95 % CL Min.#/m²	95 % CL Max.#/m²	Area m²	Total No. of urchins	95 % CL Min. No.	95 % CL Max. No.
1	29	45	58	10.8	22.2	23	67	441,558	19,968,319	10,180,480	29,756,157
2	25	7	10	2.1	4.3	3	11	1,068,704	7,686,119	3,087,636	12,284,602
3								974,218			
4								450,013			
5	6	15	3	1.2	3.1	12	18	453,706	6,748,877	5,332,527	8,165,227
7								144,283			
14	6	5	2	1.0	2.6	2	7	191,769	902,912	401,628	1,404,197
15	6	32	9	3.8	9.9	22	41	74,038	2,337,133	1,607,786	3,066,479
16	9	18	10	3.4	7.9	10	26	158,008	2,820,443	1,578,944	4,061,942
Total	**81**	**10**			**5**	**6**	**15**	**3,956,297**	**40,463,803**	**22,189,002**	**58,738,603**

C Locations (combined)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	95 % CL Min.#/m²	95 % CL Max.#/m²	Area m²	Total No. of urchins	95 % CL Min. No.	95 % CL Max. No.
1	50	58			20.1	38	79	895126	52333635	34325038	70342232
2	64	27			8.1	19	35	2571785	69214162	48509141	89919183
3	15	0.2			0.3	0	1	2070907	365563	0	1149618
4	23	9			3.4	6	12	735881	6569992	4092186	9047799
5	15	26			6.8	19	33	667382	17230872	12719768	21741975
7	15	19			7.2	12	26	587520	11113429	6911458	15315401
14	27	3			3.0	0	6	1341035	3981303	401628	8445826
15	28	65			17.5	48	82	211763	13763300	10059000	17467600
16	36	24			10.1	14	34	290597	6965568	4022615	9908521
Total	**273**	**19**			**7**	**13**	**26**	**9,371,996**	**181,537,824**	**121,040,833**	**243,338,155**

Appendix 4. Biomass calculations using mean numbers of urchins from Appendix 2 for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Campobello Island fishing area based on the 1992 survey data.

A Locations (0 to 10 m)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	95 % CL Min (t)	Max (t)		Mean	95 % CI		Total (t)	95 % CL Min (t)	Max (t)
1	17,940,359	3,523,235	26	468	376	560	14	2,497,193	490,414	66	165	132	197
2	38,491,911	6,968,558	23	873	715	1030	8	3,232,643	585,236	64	206	169	244
3	0	0	0	0	0	0		0	0		0	0	0
4	6,348,312	3,987,062	39	245	91	398	30	1,914,570	1,202,447	65	124	46	202
5	3,737,041	1,144,524	52	193	134	253	45	1,697,261	519,811	74	125	87	163
7	3,748,308	1,612,144	62	232	132	332	68	2,535,040	1,090,319	73	185	106	265
14	1,327,129	1,682,097	76	100	0	228	82	1,081,898	1,371,274	84	91	0	206
15	3,375,028	1,521,732	23	77	42	111	11	356,551	160,762	65	23	13	34
16	4,475,134	2,113,977	20	91	48	135	7	304,080	143,642	63	19	10	28
Total	**79,443,219**		**29**	**2279**	**1538**	**3047**	**17**	**13,619,235**		**69**	**938**	**562**	**1338**

B Locations (11 to 20 m)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	95 % CL Min (t)	Max (t)		Mean	95 % CI		Total (t)	95 % CL Min (t)	Max (t)
1	8,916,972	1,498,196	13	120	100	140	1	102,842	17,279	62	6	5	7
2	18,648,885	3,897,610	11	196	155	237	1	109,915	22,972	67	7	6	9
3													
4	18,090,523	0	15	265	265	265	3	467,858	0	85	40	40	40
5	12,314,115	1,909,454	15	185	156	213	2	253,030	39,235	59	15	13	17
7													
14	0	0		0	0	0		0	0		0	0	0
15	961,569	369,696	9	8	5	12	2	18,854	7,249	58	1	1	2
16	2,714,577	1,791,132	17	47	16	77	4	107,437	70,889	62	7	2	11
Total	**61,646,640**		**13**	**821**	**697**	**945**	**2**	**1,059,936**		**72**	**76**	**66**	**86**

C Locations (combined)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	95 % CL Min (t)	Max (t)		Mean	95 % CI		Total (t)	95 % CL Min (t)	Max (t)
1	26,857,331			589	476	701	10	2,600,034			171	138	204
2	57,140,795			1068	869	1267	6	3,342,558			214	175	253
3	0			0	0	0	0	0			0	0	0
4	24,438,834			510	356	664	10	2,382,428			164	86	242
5	16,051,155			378	290	466	12	1,950,290			140	99	180
7	3,748,308			232	132	332	68	2,535,040			185	106	265
14	1,327,129			100	0	228	82	1,081,898			91	0	206
15	4,336,596			85	47	123	9	375,406			24	13	35
16	7,189,711			138	64	212	6	411,517			26	12	39
Total	**141,089,859**		**22**	**3100**	**2236**	**3992**	**10**	**14,679,171**		**69**	**1014**	**629**	**1424**

Appendix 5. Biomass calculations using mean numbers of urchins from Appendix 3 for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Campobello Island fishing area based on the 2002 survey data.

A

Locations (0 to 10 m)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	Min (t)	Max (t)		Mean	95% CI		Total (t)	Min (t)	Max (t)
1	32,365,317	8,220,759	27	872	650	1093	8	2,733,071	694,197	59	163	121	204
2	61,528,043	16,106,538	28	1737	1283	2192	10	5,954,327	1,558,697	61	366	270	461
3	365,563	784,055	27	10	0	31	26	96,006	205,914	69	7	0	21
4	6,569,992	2,477,807	29	187	117	258	13	882,226	332,723	62	55	34	75
5	10,481,995	3,094,753	43	450	317	582	29	3,089,065	912,030	65	201	141	260
7	11,113,429	4,201,972	39	437	272	602	25	2,778,357	1,050,493	63	175	109	242
14	3,078,391	3,963,239	37	114	0	262	13	386,658	497,798	64	25	0	56
15	11,426,167	2,974,954	18	210	155	265	6	663,027	172,628	60	40	29	50
16	4,145,125	1,701,454	26	107	63	150	13	526,517	216,120	62	33	19	46
Total	141,074,021		29	4124	2856	5435	12	17,109,255		62	1063	725	1416

B

Locations (11 to 20 m)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	Min (t)	Max (t)		Mean	95% CI		Total (t)	Min (t)	Max (t)
1	19,968,319	9,787,838	12	243	124	362	1	254,779	124,885	58	15	7	22
2	7,686,119	4,598,483	26	202	81	324	17	1,323,438	791,792	66	87	35	139
3													
4													
5	6,748,877	1,416,350	32	214	169	259	14	935,488	196,326	63	59	47	72
7													
14	902,912	501,284	33	29	13	46	14	123,929	68,804	65	8	4	12
15	2,337,133	729,346	3	8	5	10	0	0	0		0	0	0
16	2,820,443	1,241,499	16	45	25	65	4	126,154	55,530	66	8	5	12
Total	40,463,803		18	742	418	1066	7	2,763,788		64	177	97	257

C

Locations (combined)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	Min (t)	Max (t)		Mean	95% CI		Total (t)	Min (t)	Max (t)
1	52,333,635			1115	774	1455	6	2,987,850			177	129	226
2	69,214,162			1940	1364	2516	11	7,277,764			452	305	600
3	365,563			10	0	31	26	96,006			7	0	21
4	6,569,992			187	117	258	13	882,226			55	34	75
5	17,230,872			664	486	841	23	4,024,553			260	188	332
7	11,113,429			437	272	602	25	2,778,357			175	109	242
14	3,981,303			144	13	307	13	510,587			33	4	69
15	13,763,300			218	161	275	5	663,027			40	29	50
16	6,965,568			152	88	216	9	652,671			41	24	58
Total	181,537,824		27	4866	3275	6501	11	19,873,043		62	1240	822	1673

Appendix 6. Calculation of mean, minimum, and maximum number of sea urchins for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Deer Island fishing area based on the 1993-94 survey data.

A Locations	No of	Mean		STD	95 % CL			Area m²	Total No.	95 % CL	
(0 to 10 m)	Sections	#/m²	SD	ERROR	Mean	Min.#/m²	Max. #/m²		of urchins	Min. No.	Max. No.
18	49	40	39	5.6	11.2	29	51	909,150	36,355,795	26,160,270	46,551,320
19	153	7	13	1.1	2.1	5	9	1,815,680	13,361,269	9,576,195	17,146,342
20	18	43	23	5.3	11.3	32	55	635,923	27,614,956	20,446,268	34,783,644
24	47	49	33	4.8	9.7	39	58	807,432	39,388,079	31,584,521	47,191,637
25	13	66	28	7.9	17.1	49	83	528,021	34,959,052	25,914,798	44,003,306
29	20	59	19	4.2	8.8	50	68	421,310	24,853,077	21,124,603	28,581,550
30	21	58	30	5.7	11.6	46	69	754,969	43,666,868	34,911,157	52,422,579
31	1	58	0	0.0	0.0	58	58	158,681	9,124,158	9,124,158	9,124,158
32	10	78	34	10.6	24.0	54	102	668,448	51,998,570	35,933,875	68,063,265
Total	**332**	**42**			**10**	**32**	**52**	**6,699,614**	**281,321,823**	**214,775,845**	**347,867,802**

B Locations	No of	Mean		STD	95 % CL			Area m²	Total No.	95 % CL	
(11 to 20 m)	Sections	#/m²	SD	ERROR	Mean	Min.#/m²	Max. #/m²		of urchins	Min. No.	Max. No.
18	11	0.1	0.1	0.04	0.1	0.01	0.2	331,103	31,605	3,270	59,941
19	46	2	2	0.3	0.6	1	2	638,639	996,832	596,341	1,397,323
20	23	18	15	3.0	6.3	12	24	516,388	9,366,829	6,101,591	12,632,067
24	29	32	25	4.7	9.7	23	42	406,969	13,167,552	9,222,160	17,112,944
25	15	37	14	3.7	7.9	29	45	327,350	11,967,916	9,368,291	14,567,541
29	7	45	12	4.6	11.4	34	56	324,480	14,592,329	10,904,844	18,279,814
30	31	21	11	2.0	4.1	17	26	467,804	10,029,869	8,118,440	11,941,297
31	6	28	17	6.8	17.4	10	45	175,047	4,866,307	1,828,524	7,904,089
32	15	31	26	6.6	14.3	17	45	801,377	24,730,494	13,307,454	36,153,534
Total	**183**	**22**			**8**	**15**	**30**	**3,989,157**	**89,749,734**	**59,450,915**	**120,048,552**

C Locations	No of	Mean		STD	95 % CL			Area m²	Total No.	95 % CL	
(combined)	Sections	#/m²	SD	ERROR	Mean	Min.#/m²	Max. #/m²		of urchins	Min. No.	Max. No.
18	60	29				21	38	1,240,253	36,387,401	26,163,540	46,611,261
19	199	6				4	8	2,454,319	14,358,101	10,172,537	18,543,665
20	41	32				23	41	1,152,311	36,981,786	26,547,860	47,415,712
24	76	43				34	53	1,214,401	52,555,631	40,806,681	64,304,582
25	28	55				41	68	855,371	46,926,968	35,283,088	58,570,847
29	27	53				43	63	745,790	39,445,406	32,029,448	46,861,365
30	52	44				35	53	1,222,773	53,696,736	43,029,597	64,363,876
31	7	42				33	51	333,728	13,990,464	10,952,682	17,028,247
32	25	52				34	71	1,469,825	76,729,064	49,241,329	104,216,799
Total	**515**	**35**			**9**	**26**	**44**	**10,688,771**	**371,071,557**	**274,226,760**	**467,916,354**

Appendix 7. Calculation of mean, minimum, and maximum number of sea urchins for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Deer Island fishing area based on the 2002-03 survey data.

A Locations (0 to 10 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
18	36	32	31	5.1	10	22	42	909,150	29,092,800	20,001,300	38,184,300
19	121	8	17	1.6	3	5	11	1,815,680	14,162,304	8,715,264	19,609,344
20	6	57	32	12.9	33	24	90	635,923	36,056,834	15,071,375	57,042,293
24	41	43	37	5.7	12	32	55	807,432	34,800,319	25,514,851	44,085,787
25	6	59	52	21.1	54	5	113	528,021	31,311,645	2,798,511	59,824,779
29	28	22	30	5.6	12	10	33	421,310	9,142,427	4,297,362	13,987,492
30	27	30	34	6.5	13	17	44	754,969	22,875,561	12,758,976	32,992,145
31	1	46		0.0		46	46	158,681	7,219,986	7,219,986	7,219,986
32	9	47	37	12.4	29	18	75	668,448	31,149,677	12,032,064	50,267,290
Total	**275**	**32**			**16**	**16**	**48**	**6,699,614**	**215,811,553**	**108,409,689**	**323,213,416**

B Locations (11 to 20 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
18	17	0	0	0.0	0.0	0	0	331,103	0	0	0
19	54	1	3	0.4	0.7	0.2	1.580	638,639	555,616	102,182.2	1,009,050
20	10	4	4	1.2	2.6	2	7	516,388	2,194,649	844,294	3,545,004
24	17	16	19	4.6	9.8	6	26	406,969	6,591,677	2,585,881	10,597,473
25	4	5	6	3.2	10.1	0	15	327,350	1,751,323	0	5,067,051
29	12	10	7	1.9	4.2	6	15	324,480	3,366,480	2,005,286	4,727,674
30	26	16	13	2.5	5.2	11	21	467,804	7,339,845	4,913,813	9,765,876
31	3	20	24	13.8	59.4	0	79	175,047	3,503,741	0	13,894,706
32	8	31	30	10.7	25.4	6	57	801,377	24,987,736	4,643,178	45,332,294
Total	**151**	**13**			**10**	**4**	**24**	**3,989,157**	**50,291,066**	**15,094,636**	**93,939,126**

C Locations (combined)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
18	53	23				16	31	1,240,253	29,092,800	20,001,300	38,184,300
19	175	6				4	8	2,454,319	14,717,920	8,817,446	20,618,394
20	16	33				14	53	1,152,311	38,251,483	15,915,669	60,587,297
24	58	34				23	45	1,214,401	41,391,996	28,100,732	54,683,260
25	10	39				3	76	855,371	33,062,968	2,798,511	64,891,830
29	40	17				8	25	745,790	12,508,907	6,302,648	18,715,166
30	53	25				14	35	1,222,773	30,215,405	17,672,789	42,758,022
31	4	32				22	63	333,728	10,723,726	7,219,986	21,114,691
32	17	38				11	65	1,469,825	56,137,413	16,675,242	95,599,584
Total	**426**	**25**			**14**	**12**	**39**	**10,688,771**	**266,102,619**	**123,504,325**	**417,152,542**

Appendix 8. Biomass calculations using mean numbers of urchins from Appendix 6 for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Deer Island fishing area based on the 1992-93 survey data.

A Locations (0 to 10 m)	Total Number of Urchins Mean	95% CI	Mean Weight (g)	Total Biomass (t) Total (t)	95 % CL Min (t)	Max (t)	Percent Fishable %	Number of legal size urchins (≥ 51 mm TD) Mean	95 % CI	Legal Mean Wt. (g)	Legal Size Biomass (t) Total (t)	95 % CL Min (t)	Max (t)
18	36,355,795	10,195,525	24	869	625	1113	11	3,942,479	1,105,619	64	253	182	324
19	13,361,269	3,785,073	52	693	497	890	43	5,760,867	1,631,978	79	454	325	582
20	27,614,956	7,168,688	20	566	419	713	4	1,092,310	283,557	64	70	52	88
24	39,388,079	7,803,558	30	1196	959	1433	18	7,022,681	1,391,332	68	475	381	569
25	34,959,052	9,044,254	12	437	324	549	2	535,088	138,432	66	35	26	45
29	24,853,077	3,728,473	22	548	466	630	11	2,699,098	404,920	67	181	154	208
30	43,666,868	8,755,711	26	1134	907	1361	15	6,652,117	1,333,826	67	449	359	539
31	9,124,158	0	32	294	294	294	18	1,621,043	0	81	99	99	99
32	51,998,570	16,064,695	29	1532	1059	2005	15	8,030,980	2,481,131	65	523	361	685
Total	**281,321,823**		**26**	**7269**	**5549**	**8989**	**13**	**37,356,662**		**68**	**2538**	**1938**	**3137**

B Locations (11 to 20 m)	Total Number of Urchins Mean	95% CI	Mean Weight (g)	Total Biomass (t) Total (t)	95 % CL Min (t)	Max (t)	Percent Fishable %	Number of legal size urchins (≥ 51 mm TD) Mean	95 % CI	Legal Mean Wt. (g)	Legal Size Biomass (t) Total (t)	95 % CL Min (t)	Max (t)
18	31,605	28,336	0	0	0	0	0	0	0	0	0	0	0
19	996,832	400,491	47	46	28	65	40	400,179	160,778	78	31	19	44
20	9,366,829	3,265,238	16	152	99	205	4	329,818	114,973	66	22	14	29
24	13,167,552	3,945,392	26	337	236	438	18	2,400,335	719,212	79	190	133	247
25	11,967,916	2,599,625	17	205	160	249	6	707,615	153,705	65	46	36	56
29	14,592,329	3,687,485	12	179	134	224	3	444,888	112,423	65	29	22	36
30	10,029,869	1,911,429	10	104	84	124	2	234,960	44,777	71	17	14	20
31	4,866,307	3,037,783	18	88	33	143	11	524,798	327,604	66	35	13	57
32	24,730,494	11,423,040	12	301	162	439	4	881,800	407,305	65	57	31	84
Total	**89,749,734**		**16**	**1412**	**936**	**1888**	**7**	**5,924,393**		**72**	**427**	**281**	**573**

C Locations (combined)	Total Number of Urchins Mean	95% CI	Mean Weight (g)	Total Biomass (t) Total (t)	95 % CL Min (t)	Max (t)	Percent Fishable %	Number of legal size urchins (≥ 51 mm TD) Mean	95 % CI	Legal Mean Wt. (g)	Legal Size Biomass (t) Total (t)	95 % CL Min (t)	Max (t)
18	36,387,401			869	625	1,113	11	3,942,479			253	182	324
19	14,358,101			740	525	955	43	6,161,046			485	344	626
20	36,981,786			718	518	918	0	1,422,128			92	66	117
24	52,555,631			1,533	1,195	1,871	18	9,423,016			665	514	816
25	46,926,968			641	484	799	3	1,242,702			81	62	100
29	39,445,406			727	599	854	8	3,143,986			210	175	244
30	53,696,736			1,238	991	1,486	13	6,887,077			465	372	559
31	13,990,464			383	327	438	15	2,145,841			133	112	155
32	76,729,064			1,833	1,220	2,445	12	8,912,781			580	392	768
Total	**371,071,557**		**23**	**8681**	**6485**	**10877**	**12**	**43,281,056**		**69**	**2965**	**2219**	**3710**

Appendix 9. Biomass calculations using mean numbers of urchins from Appendix 7 for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Deer Island fishing area based on the 2002-03 survey data.

A

Locations (0 to 10 m)	Total Number of Urchins Mean	95% CI	Mean Weight (g)	Total Biomass (t) Total (t)	95 % CL Min (t)	Max (t)	Percent Fishable %	Number of legal size urchins (≥ 51 mm TD) Mean	95 % CI	Legal Mean Wt. (g)	Legal Size Biomass (t) Total (t)	95 % CL Min (t)	Max (t)
18	29,092,800	9,091,500	19	559	384	734	9	2,502,606	782,065	61	153	105	200
19	14,162,304	5,447,040	32	457	282	633	13	1,832,071	704,643	65	118	73	164
20	36,056,834	20,985,459	25	899	376	1421	6	2,043,440	1,189,304	68	138	58	219
24	34,800,319	9,285,468	26	897	658	1136	9	3,109,154	829,589	62	192	141	243
25	31,311,645	28,513,134	23	722	65	1379	6	1,744,381	1,588,475	61	107	10	205
29	9,142,427	4,845,065	29	269	126	412	13	1,212,437	642,536	61	74	35	113
30	22,875,561	10,116,585	23	520	290	749	6	1,423,515	629,541	62	89	49	128
31	7,219,986	0	27	197	197	197	3	208,269	0	62	13	13	13
32	31,149,677	19,117,613	24	749	289	1208	7	2,130,520	1,307,573	64	136	53	220
Total	**215,811,553**		**24**	**5268**	**2666**	**7870**	**8**	**16,206,394**		**63**	**1020**	**536**	**1505**

B

Locations (11 to 20 m)	Total Number of Urchins Mean	95% CI	Mean Weight (g)	Total Biomass (t) Total (t)	95 % CL Min (t)	Max (t)	Percent Fishable %	Number of legal size urchins (≥ 51 mm TD) Mean	95 % CI	Legal Mean Wt. (g)	Legal Size Biomass (t) Total (t)	95 % CL Min (t)	Max (t)
18	0	0		0	0	0		0	0		0	0	0
19	555,616	453,434	27	15	3	27	12	64,695	52,797	63	4	1	7
20	2,194,649	1,350,355	24	52	20	84	7	148,430	91,328	64	9	4	15
24	6,591,677	4,005,796	18	118	46	189	9	566,852	344,479	68	38	15	62
25	1,751,323	3,315,728		0	0	0		0	0		0	0	0
29	3,366,480	1,361,194	19	63	38	89	7	219,172	88,619	66	15	9	20
30	7,339,845	2,426,032	9	67	45	89	1	70,575	23,327	64	4	3	6
31	3,503,741	10,390,965	39	136	0	537	20	688,235	2,041,082	58	40	0	159
32	24,987,736	20,344,558	18	444	82	805	4	1,063,308	865,726	64	68	13	124
Total	**50,291,066**		**18**	**894**	**234**	**1821**	**6**	**2,821,267**		**64**	**179**	**44**	**394**

C

Locations (combined)	Total Number of Urchins Mean	95% CI	Mean Weight (g)	Total Biomass (t) Total (t)	95 % CL Min (t)	Max (t)	Percent Fishable %	Number of legal size urchins (≥ 51 mm TD) Mean	95 % CI	Legal Mean Wt. (g)	Legal Size Biomass (t) Total (t)	95 % CL Min (t)	Max (t)
18	29,092,800			559	384	734	9	2,502,606			153	105	200
19	14,717,920			472	284	661	13	1,896,766			122	74	171
20	38,251,483			951	396	1,506	0	2,191,871			148	61	234
24	41,391,996			1,015	704	1,325	9	3,676,006			230	156	305
25	33,062,968			722	65	1,379	5	1,744,381			107	10	205
29	12,508,907			332	164	500	11	1,431,608			88	43	133
30	30,215,405			587	335	839	5	1,494,091			93	53	134
31	10,723,726			332	197	734	8	896,504			53	13	172
32	56,137,413			1,193	372	2,014	6	3,193,828			205	65	344
Total	**266,102,619**		**23**	**6162**	**2900**	**9691**	**7**	**19,027,662**		**63**	**1200**	**579**	**1899**

Appendix 10. Calculation of mean, minimum, and maximum number of sea urchins for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Letete to Pocologan fishing area based on the 1993-94 survey data.

A Locations (0 to 10 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
35	52	121	62	8.6	17	104	138	916,123	110,759,278	95,276,798	126,424,982
36	17	61	44	10.6	22	39	83	296,009	17,908,541	11,544,349	24,568,743
37	33	5	9	1.6	3	2	8	913,346	4,475,395	1,826,692	7,306,767
38	35	37	36	6.0	12	25	49	1,480,111	55,208,125	37,002,765	72,525,419
43	7	23	30	11.3	28	0	51	431,145	9,959,453	0	21,988,402
45	17	22	29	7.0	15	7	37	469,486	10,375,645	3,286,403	17,370,990
46	9	34	16	5.4	13	21	50	439,760	14,819,904	9,234,955	21,987,988
48	15	52	14	3.5	8	44	60	567,150	29,605,245	24,954,613	34,029,017
53	84	16	21	2.3	5	11	21	2,247,236	35,506,334	24,719,600	47,191,963
54	26	2	6	1.3	3	0	5	3,396,153	6,792,306	0	16,980,765
Total	**295**	**26**			**8**	**18.63**	**34.99**	**11,156,519**	**295,410,226**	**207,846,175**	**390,375,036**

B Locations (11 to 20 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
35	17	129	56	13.5	29	100	158	384,497	49,561,656	38,449,694	60,750,517
36	35	4	11	1.9	4	0	8	493,139	2,169,812	0	3,945,112
37	7	4	7	2.7	7	0	11	294,989	1,120,959	0	3,244,881
38	27	6	11	2.1	4	2	10	1,662,908	9,977,450	3,325,817	16,629,084
43	17	1	1	0.3	1	0	2	50,906	50,906	0	101,812
45	43	5	12	1.8	4	8	16	151,559	682,015	1,212,470	2,424,941
46	11	5	7	2.0	4	3	11	416,349	2,040,111	1,249,048	4,579,842
48	26	11	17	3.3	7	10	24	566,880	6,122,301	5,668,797	13,605,113
53	21	14	16	3.6	7	7	21	1,634,236	22,062,182	11,439,650	34,318,949
54	4	0	0	0.0	0	0	0	0	0	0	0
Total	**208**	**17**			**7**	**11**	**25**	**5,655,463**	**93,787,391**	**61,345,476**	**139,600,250**

C Locations (combined)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
35	69	123				103	144	1,300,620	160,320,934	133,726,492	187,175,499
36	52	25				15	36	789,148	20,078,353	11,544,349	28,513,855
37	40	5				2	9	1,208,335	5,596,353	1,826,692	10,551,647
38	62	21				13	28	3,143,019	65,185,576	40,328,582	89,154,503
43	24	21				0	46	482,051	10,010,358	0	22,090,213
45	60	18				7	32	621,045	11,057,660	4,498,874	19,795,930
46	20	20				12	31	856,109	16,860,015	10,484,003	26,567,830
48	41	32				27	42	1,134,030	35,727,546	30,623,410	47,634,130
53	105	15				9	21	3,881,472	57,568,516	36,159,249	81,510,912
54	30	2				0	5	3,396,153	6,792,306	0	16,980,765
Total	**503**	**23**			**8**	**16**	**32**	**16,811,982**	**389,197,617**	**269,191,650**	**529,975,286**

Appendix 11. Calculation of mean, minimum, and maximum number of sea urchins for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Letete to Pocologan fishing area based on the 2003 survey data.

A Locations (0 to 10 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
35	35	75	43	7.2	15	60	90	916,123	68,709,230	55,242,221	82,176,238
36	27	30	40	7.7	16	14	45	296,009	8,732,264	4,025,722	13,438,806
37	34	1	3	0.6	1	0	2	913,346	639,342	0	1,644,023
38	37	22	44	7.2	15	8	37	1,480,111	32,710,444	11,248,841	54,172,048
43	6	60	38	15.4	40	21	100	431,145	26,041,166	8,967,819	43,114,513
45	10	57	53	16.8	38	19	94	469,486	26,525,971	8,732,444	44,319,498
46	18	50	37	8.7	18	32	68	439,760	21,987,988	13,940,384	30,035,592
48	28	54	45	8.4	17	36	71	567,150	30,399,256	20,587,556	40,210,956
53	92	26	30	3.1	6	20	33	2,247,236	59,327,039	45,394,174	73,259,904
54	30	10	15	2.8	6	5	16	3,396,153	35,319,991	15,961,919	54,678,063
Total	317	28			11	17	39	11,156,519	310,392,690	184,101,078	437,049,641

B Locations (11 to 20 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
35	17	97	40	9.6	20	77	117	384,497	37,296,203	29,452,466	45,139,941
36	15	3	5	1.2	3	1	6	493,139	1,578,045	295,883	2,860,206
37	4	0.4	1	0.3	1	0	2	294,989	117,996	0	442,484
38	20	1	3	0.6	1	0	2	1,662,908	1,995,490	0	3,990,980
43	2	4	4	2.7	35	0	39	50,906	208,714	0	1,970,057
45	15	13	17	4.4	9	4	23	151,559	2,015,732	606,235	3,425,229
46	3	0.4	1	0.4	2	0	2	416,349	166,540	0	832,698
48	8	9	20	7.1	17	0	25	566,880	4,875,166	0	14,398,745
53	9	0	0	0	0	0	0	1,634,236	0	0	0
54											
Total	93	9			4	5	13	5,655,463	48,253,885	30,354,584	73,060,340

C Locations (combined)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min.#/m²	Max. #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
35	52	82				65	98	1,300,620	106,005,433	84,694,686	127,316,179
36	42	13				5	21	789,148	10,310,309	4,321,605	16,299,013
37	38	1				0.0	2	1,208,335	757,338	0	2,086,506
38	57	11				4	19	3,143,019	34,705,934	11,248,841	58,163,028
43	8	54				19	94	482,051	26,249,880	8,967,819	45,084,570
45	25	46				15	77	621,045	28,541,703	9,338,679	47,744,727
46	21	26				16	36	856,109	22,154,528	13,940,384	30,868,290
48	36	31				18	48	1,134,030	35,274,421	20,587,556	54,609,700
53	101	15				12	19	3,881,472	59,327,039	45,394,174	73,259,904
54	30	10				5	16	3,396,153	35,319,991	15,961,919	54,678,063
Total	410	21			9	13	30	16,811,982	358,646,575	214,455,662	510,109,981

Appendix 12. Biomass calculations using mean numbers of urchins from Appendix 10 for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Letete to Pocologan fishing area based on the 1993-94 survey data.

A Locations (0 to 10 m)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	Min (t)	Max (t)		Mean	95% CI		Total (t)	Min (t)	Max (t)
35	110,759,278	15,757,317	19	2065	1771	2358	10	11,243,382	1,599,555	68	763	654	872
36	17,908,541	6,630,600	28	503	317	689	19	3,396,448	1,257,528	69	234	147	321
37	4,475,395	3,014,041	36	163	53	272	26	1,145,546	771,490	74	85	28	143
38	55,208,125	18,205,360	29	1579	1058	2100	15	8,390,872	2,766,963	69	582	390	774
43	9,959,453	11,942,720	36	354	0	778	21	2,049,074	2,457,115	71	146	0	321
45	10,375,645	6,995,345	35	365	119	612	27	2,836,598	1,912,457	78	222	72	371
46	14,819,904	5,540,973	22	320	200	439	12	1,816,447	679,146	69	125	78	171
48	29,605,245	4,253,627	26	781	669	893	13	3,914,230	562,389	66	258	221	295
53	35,506,334	10,337,287	32	1144	811	1477	25	8,985,438	2,616,014	75	674	478	870
54	6,792,306	8,829,998	25	167	0	383	9	625,607	813,289	62	39	0	90
Total	295,410,226		25	7438	4997	10000	15	44,403,642		70	3128	2069	4227

B Locations (11 to 20 m)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	Min (t)	Max (t)		Mean	95% CI		Total (t)	Min (t)	Max (t)
35	49,561,656	10,996,612	11	550	428	672	2	840,028	186,383	64	54	42	66
36	2,169,812	1,873,928	31	68	9	126	17	369,169	318,828	72	27	4	49
37	1,120,959	1,917,429	63	71	0	192	62	690,692	1,181,446	81	56	0	151
38	9,977,450	7,316,797	30	298	79	516	19	1,896,947	1,391,095	77	145	39	252
43	50,906	35,634	27	1	0	2	19	9,446	6,613	72	1	0	1
45	682,015	545,612	35	24	5	43	35	236,674	189,340	82	19	4	35
46	2,040,111	1,831,937	36	74	8	141	25	519,724	466,691	84	44	4	83
48	6,122,301	3,798,094	43	260	99	422	32	1,978,926	1,227,667	83	163	62	265
53	22,062,182	12,093,344	16	357	161	552	6	1,337,102	732,930	63	85	38	131
54													
Total	93,787,391		18	1703	789	2667	8	7,878,709		75	593	193	1033

C Locations (combined)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	Min (t)	Max (t)		Mean	95% CI		Total (t)	Min (t)	Max (t)
35	160,320,934			2614	2199	3030	8	12,083,410			817	696	937
36	20,078,353			570	326	815	19	3,765,617			261	151	370
37	5,596,353			233	53	464	33	1,836,237			141	28	293
38	65,185,576			1877	1138	2616	16	10,287,820			728	429	1026
43	10,010,358			355	0	781	21	2,058,520			146	0	322
45	11,057,660			389	124	655	28	3,073,272			241	76	406
46	16,860,015			394	208	580	14	2,336,172			169	83	254
48	35,727,546			1041	767	1315	16	5,893,155			421	283	560
53	57,568,516			1500	972	2029	18	10,322,540			758	516	1001
54	6,792,306			167	0	383	9	625,607			39	0	90
Total	389,197,617		23	9141	5786	12667	13	52,282,351		71	3721	2262	5260

Appendix 13. Biomass calculations using mean numbers of urchins from Appendix 11 for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Letete to Pocologan fishing area based on the 2003 survey data.

A Locations (0 to 10 m)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	95 % CL Min (t)	Max (t)		Mean	95 % CI		Total (t)	95 % CL Min (t)	Max (t)
35	68,709,230	13,467,009	20	1387	1115	1658	4	2,860,962	560,749	59	168	135	201
36	8,732,264	4,706,542	28	243	112	374	10	887,282	478,230	62	55	25	85
37	639,342	1,004,680	40	26	0	66	17	109,476	172,034	59	6	0	17
38	32,710,444	21,461,604	28	909	312	1505	14	4,435,314	2,910,048	64	285	98	473
43	26,041,166	17,073,347	28	720	248	1191	7	1,902,551	1,247,368	61	116	40	192
45	26,525,971	17,793,527	27	716	236	1197	8	2,040,459	1,368,733	62	126	42	211
46	21,987,988	8,047,604	24	532	337	727	9	2,034,322	744,562	63	128	81	175
48	30,399,256	9,811,700	22	656	444	868	8	2,409,549	777,709	63	153	104	202
53	59,327,039	13,932,865	27	1590	1217	1963	18	10,882,976	2,555,850	69	754	577	931
54	35,319,991	19,358,072	34	1201	543	1860	25	8,932,672	4,895,791	69	620	280	960
Total	310,392,690		26	7980	4564	11410	12	36,495,564		66	2412	1382	3446

B Locations (11 to 20 m)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	95 % CL Min (t)	Max (t)		Mean	95 % CI		Total (t)	95 % CL Min (t)	Max (t)
35	37,296,203	7,843,738	8	308	244	373	1	258,403	54,345	62	16	13	19
36	1,578,045	1,282,162	9	14	3	25	0	0	0	0	0	0	0
37	117,996	324,488	50	6	0	22	45	52,600	144,651	68	4	0	13
38	1,995,490	1,995,490	43	85	0	170	36	708,781	708,781	92	65	0	130
43	208,714	1,761,343	26	5	0	51	6	12,277	103,608	62	1	0	7
45	2,015,732	1,409,497	32	65	20	111	23	463,667	324,218	73	34	10	57
46	166,540	666,159	0	0	0	0	0	0	0	0	0	0	0
48	4,875,166	9,523,579	30	148	0	438	27	1,293,411	2,526,664	77	100	0	294
53	0	0	0	0	0	0	0	0	0	0	0	0	0
54													
Total	48,253,885		13	632	266	1191	6	2,789,140		78	218	23	521

C Locations (combined)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	95 % CL Min (t)	Max (t)		Mean	95 % CI		Total (t)	95 % CL Min (t)	Max (t)
35	106,005,433			1695	1358	2032	3	3,119,365			184	148	220
36	10,310,309			257	115	399	9	887,282			55	25	85
37	757,338			32	0	88	21	162,077			10	0	30
38	34,705,934			994	312	1675	15	5,144,095			350	98	602
43	26,249,880			725	248	1242	7	1,914,828			117	40	199
45	28,541,703			782	255	1308	9	2,504,126			160	52	268
46	22,154,528			532	337	727	9	2,034,322			128	81	175
48	35,274,421			804	444	1306	10	3,702,960			253	104	496
53	59,327,039			1590	1217	1963	18	10,882,976			754	577	931
54	35,319,991			1201	543	1860	25	8,932,672			620	280	960
Total	358,646,575		24	8612	4830	12600	11	39,284,704		67	2631	1405	3967

Appendix 14. Calculation of mean, minimum, and maximum number of sea urchins for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Maces Bay fishing area based on the 2002 survey data.

A Locations (0 to 10 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min #/m²	Max #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
55	30	4	10	1.9	3.8	0.0	7.5	1.001.673	3.741.249	0	7.537.589
56	15	0	0	0.0	0.0	0.0	0.0	755.659	0	0	0
57	43	13	11	1.7	3.5	9.5	16.5	1.247.928	16.223.064	11.855.316	20.590.812
58	15	0	0	0.1	0.2	0.0	0.4	1.368.184	273.637	0	547.274
59	109	35	41	4.0	7.9	26.9	42.6	1.872.832	65.077.166	50.375.435	79.778.898
60	90	27	28	2.9	5.8	21.4	33.0	1.399.227	38.058.974	29.943.458	46.174.491
61	145	11	14	1.1	2.3	8.9	13.4	2.066.984	23.098.546	18.420.961	27.776.131
62	69	6	9	1.1	2.1	4.2	8.4	1.166.801	7.350.846	4.900.564	9.801.128
63	25	7	5	1.0	2.1	4.6	8.7	545.135	3.640.412	2.516.343	4.764.480
64	48	3	2	0.3	0.7	1.9	3.3	871.311	2.265.409	1.662.461	2.868.356
65	30	1	3	0.6	1.2	0.2	2.6	1.041.000	1.457.400	208.200	2.706.600
Total	619	12			3	9	15	13,336,734	161,186,703	119,882,739	202,545,759

B Locations (11 to 20 m)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min #/m²	Max #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
55								123.124			
56											
57											
58								38.519			
59	21	2	4	0.8	1.8	0.3	3.8	778.465	1.616.093	251.444	2.980.742
60											
61	19	12	10	2.4	5.0	7.1	17.0	347.101	4.179.790	2.452.269	5.907.312
62	33	3	7	1.3	2.6	0.1	5.3	861.660	2.326.482	86.166	4.566.798
63	20	0.1	0	0.1	0.2	0.0	0.3	445.972	53.517	0	136.913
64	18	2	2	0.5	1.1	0.5	2.6	275.556	426.285	129.511	723.059
65						0.0	0.0	237.721			
Total	111	3			2	1	5	3,108,118	8,602,167	2,919,390	14,314,825

C Locations (combined)	No of Sections	Mean #/m²	SD	STD ERROR	95 % CL Mean	Min #/m²	Max #/m²	Area m²	Total No. of urchins	95 % CL Min. No.	Max. No.
55	30	3				0	7	1.124.797	3.741.249	0	7.537.589
56	15	0				0	0	755.659	0	0	0
57	43	13				10	17	1.247.928	16.223.064	11.855.316	20.590.812
58	15	0.2				0	0.4	1.406.703	273.637	0	547.274
59	130	25				19	31	2.651.297	66.693.260	50.626.879	82.759.640
60	90	27				21	33	1.399.227	38.058.974	29.943.458	46.174.491
61	164	11				9	14	2.414.085	27.278.336	20.873.230	33.683.443
62	102	5				2	7	2.028.461	9.677.328	4.986.730	14.367.926
63	45	4				3	5	991.107	3.693.928	2.516.343	4.901.393
64	66	2				2	3	1.146.867	2.691.694	1.791.973	3.591.415
65	30	1				0.2	2	1.278.721	1.457.400	208.200	2.706.600
Total	730	10			3	7	13	16,444,852	169,788,870	122,802,129	216,860,583

Appendix 15. Biomass calculations using mean numbers of urchins from Appendix 14 for each location in the 0 to 10 m depth stratum (A), the 11 to 20 m depth stratum (B), and combined depth stratum (C), for the Maces Bay fishing area based on the 2002 survey data.

A Locations (0 to 10 m)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	Min (t)	Max (t)		Mean	95 % CI		Total (t)	Min (t)	Max (t)
55	3,741,249	3,796,341	38	141	0	284	22	823,831	835,962	67	55	0	111
56	0	0		0	0	0		0	0		0	0	0
57	16,223,064	4,367,748	35	562	411	713	24	3,864,551	1,040,456	64	246	180	312
58	273,637	273,637	25	7	0	14	27	72,739	72,739	73	5	0	11
59	65,077,166	14,701,731	32	2106	1631	2582	22	14,352,683	3,242,447	69	990	766	1214
60	38,058,974	8,115,517	21	786	619	954	9	3,451,311	735,941	65	225	177	273
61	23,098,546	4,677,585	37	854	681	1026	28	6,437,776	1,303,686	71	458	365	551
62	7,350,846	2,450,282	56	409	272	545	49	3,599,334	1,199,778	82	297	198	396
63	3,640,412	1,124,068	46	168	116	219	35	1,262,500	389,828	73	92	64	120
64	2,265,409	602,947	60	136	100	172	53	1,192,863	317,485	86	103	75	130
65	1,457,400	1,249,200	44	64	9	120	36	519,160	444,994	75	39	6	73
Total	161,186,703		32	5232	3837	6629	22	35,576,747		71	2,510	1,830	3,190

B Locations (11 to 20 m)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	Min (t)	Max (t)		Mean	95 % CI		Total (t)	Min (t)	Max (t)
55													
56													
57													
58													
59	1,616,093	1,364,649	22	36	6	67	19	307,058	259,283	75	23	4	43
60													
61	4,179,790	1,727,522	29	119	70	169	19	778,422	321,725	74	58	34	82
62	2,326,482	2,240,316	55	128	5	252	48	1,110,895	1,069,751	86	95	4	187
63	53,517	83,397	51	3	0	7	44	23,314	36,331	87	2	0	5
64	426,285	296,774	57	24	7	41	47	201,431	140,234	87	17	5	30
65													
Total	8,602,167		36	311	88	535	28	2,421,121		81	196	46	347

C Locations (combined)	Total Number of Urchins		Mean Weight (g)	Total Biomass (t)			Percent Fishable %	Number of legal size urchins (≥ 51 mm TD)		Legal Mean Wt. (g)	Legal Size Biomass (t)		
	Mean	95% CI		Total (t)	Min (t)	Max (t)		Mean	95 % CI		Total (t)	Min (t)	Max (t)
55	3,741,249			141	0	284	22	823,831			55	0	111
56	0			0	0	0	0	0			0	0	0
57	16,223,064			562	411	713	24	3,864,551			246	180	312
58	273,637			7	0	14	27	72,739			5	0	11
59	66,693,260			2143	1636	2649	22	14,659,741			1013	770	1256
60	38,058,974			786	619	954	9	3,451,311			225	177	273
61	27,278,336			973	751	1195	26	7,216,198			516	399	632
62	9,677,328			537	277	796	48	4,710,229			392	201	583
63	3,693,928			170	116	226	35	1,285,814			94	64	125
64	2,691,694			160	107	213	52	1,394,295			120	81	160
65	1,457,400			64	9	120	36	519,160			39	6	73
Total	169,788,870		33	5543	3925	7165	22	37,997,868		71	2,706	1,877	3,536